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LEVEL IV

PRELIMINARY AIRWORTHINESS EVALUATION

UH-1H HELICOPTER EQUIPPED WITH MULTIPLE TARGET ELECTRONIC WARFARE SYSTEM (MULTEWS)

FINAL REPORT

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
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The United States Army Aviation Engineering Flight Activity conducted a Preliminary Airworthiness Evaluation (PAE) of a UH-1H helicopter equipped with a Multiple Target Electronic Warfare System (MULTEWS) from 13 August through 2 December 1977. The evaluation was conducted at Edwards Air Force Base, California, and required 45 flights for a total productive flight time of 41 hours. → over

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20. Abstract

The test program was terminated when the test aircraft sustained major damage during height-velocity testing. The addition of the MULTEWS equipment to the UH-1H airframe caused significant degradation in performance and handling qualities. Changes in the operator's manual should be made to reflect the changes in performance for MULTEWS configured aircraft. The MULTEWS installation also generally degraded the vibration characteristics of the UH-1H, increased structural loads, increased the maintenance workload, and degraded aircraft crashworthiness. The degradation in performance and handling qualities as well as the excessive vibrations and structural loads in the MULTEWS configured aircraft were attributed to the extremely high drag and turbulent wake of the externally mounted MULTEWS components. A total of three deficiencies were noted: excessive vibrations in autorotation above 60 knots, excessive vibrations in high-power climbing flight, and loss of directional control in low-speed right sideward flight. Additionally, five shortcomings were noted: unsatisfactory static longitudinal stability characteristics, high vibration levels in level flight, poor hover taxi characteristics, weak side-force characteristics, and an easily excited Dutch roll. An L-703 fuel control was evaluated in addition to the basic MULTEWS PAE. The L-703 fuel control eliminated the 2.5 Hz vibrations experienced in high-power climbing flight with the L-13B fuel control.

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1 9 MAY 1979

SUBJECT: Preliminary Airworthiness Evaluation UH-1H Helicopter Equipped With Multiple Target Electronic Warfare System (MULTEWS), Final Report, USAAEFA Project No. 77-09

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1. The purpose of this letter is to establish the Directorate for Development and Engineering's position on the subject report.

2. Issues arising during the test created questions with regard to the overall airworthiness of the MULTEWS configuration. The impact of the external configuration on flight performance and handling qualities were of such magnitude that a flight loads survey program was established, to be conducted by Bell Helicopter Textron, for purposes of determining if the enormous drag increase affected the fatigue life of the critical dynamic components. While this program was never completed, it became evident that the numerous problems with the MULTEWS configuration were such that it should be abandoned. Consequently, the Signals Warfare Laboratory, US Army Electronics Research and Development Command, established an improved MULTEWS configuration which is now undergoing airworthiness qualification.

3. Critical testing has been completed and the substantial reduction in external drag and operating weight due to redesign of the transmitting antennas such that they are flush mounted to the fuselage has resulted in a viable configuration. The improved MULTEWS configuration addresses each conclusion/recommendation of this report and incorporates corrective action except in those cases where the real weakness lies in the basic UH-1H configuration and improvement is not practical.

4. This Headquarters considers the test effort reported herein to be one of the best ever performed by the AEFA and clearly illustrates

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essentiality of the airworthiness qualification process in the integration of mission equipment into the rotor craft configuration.

FOR THE COMMANDER:

WALTER A. RATCLIFF
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INTRODUCTION

BACKGROUND

1. The United States Army Intelligence and Security Command (INSCOM) is managing a contract with UTL Corporation for the development of an AN/ALQ-143 Advanced Multiple Target Electronic Warfare System (MULTEWS) integrated into a UH-1H helicopter. The United States Army Aviation Systems Command (AVSCOM)* directed the United States Army Aviation Engineering Flight Activity (USAAEFA) (ref 1, app A) to conduct a Preliminary Airworthiness Evaluation (PAE) of a UH-1H helicopter modified to the MULTEWS configuration in accordance with the approved test plan (ref 2). On 4 October 1977, a debriefing was held with INSCOM and AVRADCOM outlining the results of the evaluation to date. Based on the recommendations of USAAEFA and results of the evaluation, AVRADCOM directed that the additional testing outlined in the test plan addendum (ref 3) be accomplished.

TEST OBJECTIVES

2. The basic objectives of this test were as follows:

a. Determine the handling qualities of the UH-1H helicopter configured with MULTEWS.

b. Obtain limited level flight performance data of the MULTEWS for comparison with the UH-1H equipped with an infrared (IR) suppressor kit.

c. Identify other performance characteristics which may be significantly degraded due to MULTEWS installation.

d. Evaluate the proper functioning of additional helicopter installed systems, subsystems, and allied equipment peculiar to the modified UH-1H helicopter exclusive of MULTEWS equipment operations.

Additional specific objectives which were a result of the 4 October 1977 debriefing were as follows:

a. Evaluate the safe autorotation landing (H-V) performance of the MULTEWS equipped UH-1H helicopter at 9300 pounds gross weight at an airspeed range of 50 to 60 knots calibrated airspeed (KCAS).

b. Evaluate simulated (under the hood) instrument flight.

c. Monitor selected structural loads and vibrations of the MULTEWS equipped UH-1H helicopter.

*Since redesignated the United States Army Aviation Research and Development Command (AVRADCOM).

d. Calibrate the ship's airspeed system with test boom removed.

e. Evaluate the L-703 fuel control installed on the L-13B engine.

f. Evaluate the AH-1S torque indicator installed on the MULTEWS equipped UH-1H helicopter (a torquemeter was not available for evaluation).

DESCRIPTION

3. The AN/ALQ-143 (MULTEWS) system was installed on a UH-1H helicopter, S/N 74-22338. The UH-1H has a two-bladed, teetering main rotor and is powered by one Lycoming T53-L-13B turboshaft engine. The test aircraft was equipped with the standard turned up exhaust IR suppressor kit. The external antenna assemblies on both sides of the aircraft (sta 137) were composed of a large rectangular antenna boom with four hemispherical antenna domes plus a disc-shaped receiver antenna. Other external modifications included roof-mounted radio compartment exhaust ducts, an additional ARC-114 antenna mounted on the bottom left side of the tail boom (sta 254.25), a protective screen mounted on the pilot and copilot side windows, protective sheet metal in place of plexiglass in the sliding cargo doors, and a doppler antenna located in the "Hell Hole" (sta 137.55). Internal modifications included radio equipment racks mounted on both sides of the transmission (sta 154), a forward facing operator's seat (sta 111), and console (sta 84) which housed the equipment controls, displays, and systems communication. The standard UH-1H transmission-driven generator was replaced with a 30-KVA alternator and a 4-KVA inverter (sta 137.55) with appropriate electrical interface. The standard H-model generator drive quill (P/N 204-040-369-1) was replaced with a stronger E-model quill (P/N 204-040-369-1). A doppler navigation system (AN/APN-128) was installed to provide position and attitude inputs for the MULTEWS system. An AH-1G Environmental Control Unit (ECU) (sta 195) provided equipment cooling and cabin heat. Photo A shows the external configuration. A more detailed description of the MULTEWS equipped UH-1H helicopter is provided in the operator's manual (ref 5, app A) and in appendix B.

TEST SCOPE

4. The testing of the MULTEWS configured helicopter was conducted at the USAAEFA facility at Edwards Air Force Base, California (2302-foot elevation) from 13 August through 2 December 1977. The tests were conducted on an instrumented UH-1H helicopter modified for the MULTEWS configuration (MULTEWS configuration) and with the external MULTEWS antennas removed (clean configuration). Forty-five test flights for a total of 41.1 productive hours were accomplished at the test conditions and configurations shown in tables 1 and 2. Flight limitations contained in the airworthiness release (ref 4, app A) and the operator's manual were observed during the evaluation. Handling qualities in the MULTEWS configuration were evaluated with respect to the applicable requirements of Military Specification MIL-H-8501A (ref 6) and performance was compared to data obtained during earlier H-model testing (ref 7). Ground handling and the effects of the MULTEWS installation on general aircraft maintenance were also evaluated.

Photo A. JUH-1H with MULTEWS External Boom and Antennae - Left Side.

Table 1. Performance Flight Test Conditions.[1]

Test	True Airspeed (kt)	Density Altitude (ft)	Gross Weight (lb)
Climb	40 to 80	Target altitude 5000 ±1000	9200
Level flight	30 to V_H[2]	3000, 5000, 6000, 8000, 10,000	9200
Autorotation[3]	40 to 80	Target altitude 5000 ±1000	9200
Height-velocity[4]	50 to 60	Target altitude 400 to 200 AGL	9200

[1]Mission cg: Each condition was flown with and without the MULTEWS external configuration, and at mid cg (fuselage station (FS) 136). Referred rotor speed: 318 rpm.
[2]V_H: Maximum airspeed for level flight.
[3]Rotor speed: 324 rpm.
[4]H-V test conducted at mid cg (FS 136) in MULTEWS configuration only.
AGL: Above ground level.

TEST METHODOLOGY

5. Established flight test techniques and data analysis methods were used and are described in appendix D. A handling qualities rating scale (HQRS) (fig. 1, app D) and a vibration rating scale (VRS) (fig. 2, app D) were used to augment pilot comments. The primary flight test data were obtained from calibrated test instrumentation displayed on the pilot and copilot instrument panels and additional parameters recorded on magnetic tape. A detailed listing of the test instrumentation is contained in appendix C.

Table 2. Handling Qualities General Test Conditions.[1]

Test	Calibrated Airspeed (kt)	Flight Condition	Configuration
Control position in in trimmed forward flight	40 to V_H	Level	MULTEWS
			Clean
Static longitudinal stability[2]	60, $0.95V_H$	Level	MULTEWS
			Clean
	60	Climb	MULTEWS
			Clean
		Autorotation	MULTEWS
			Clean
Static lateral-directional stability	60, $0.95V_H$	Level	MULTEWS
Maneuvering stability		Steady turns	MULTEWS
Dynamic stability		Level	MULTEWS
Sideward, rearward and low-speed forward flight characteristics	Zero to 35 KTAS	IGE, 10 to 20-ft skid height	MULTEWS
Mission flight characteristics	As required	Maneuvering	MULTEWS
Simulated engine failure	60, 80, V_H	Level	MULTEWS
	60	Climb	MULTEWS

[1]Mission gross weight: 9200 lb. Mid (FS 130) and aft (FS 140) cg. Density altitude 5000 feet except for tests in ground effect (IGE). Rotor speed: 324 rpm.
[2]±20 knots from trim.

RESULTS AND DISCUSSION

GENERAL

6. The PAE of the MULTEWS equipped UH-1H was performed to determine the effect of the MULTEWS configuration on the performance and handling qualities of the basic UH-1H airframe and rotor system. The addition of the MULTEWS equipment to the UH-1H airframe caused significant degradation in performance and handling qualities. The MULTEWS installation generally degraded the vibration characteristics of the UH-1H, increased structural loads, increased the maintenance workload, and degraded aircraft crashworthiness. Three deficiencies were noted: excessive vibrations in autorotation above 60 knots, excessive vibrations in high-power climbing flight, and the loss of directional control in low-speed right sideward flight. Additionally, five shortcomings were noted: weak static longitudinal stability, high vibration levels in level flight, poor hover taxi characteristics, weak side-force characteristics, and an easily excited Dutch roll. An L-703 fuel control was evaluated and eliminated the 2.5 Hz vibrations encountered with the L-13B fuel control.

PERFORMANCE

General

7. The addition of the MULTEWS mission equipment to the standard UH-1H resulted in a significant decrease in performance in all areas tested and may adversely affect mission capability during moderately high density altitude (H_d) operations (above 5000 ft H_d). The performance changes due to MULTEWS installation should be reflected in the operator's manual. The H-V testing showed that the minimum safe operational altitude at mission gross weight (9300 lb) and at 50 knots indicated airspeed (KIAS) is 400 feet above ground level (AGL).

Climb Performance

8. The climb performance of the MULTEWS configured helicopter was evaluated at the general conditions listed in table 1. An additional flight was performed in the clean configuration to provide a base line for comparison. The test techniques used are described in appendix D. The results of this test are presented in figures 1 through 4 in appendix E.

9. Figure 1, appendix E, compares the MULTEWS climb performance with a clean UH-1H on a standard day at the MULTEWS mission gross weight. The addition of the MULTEWS systems and equipment caused a decrease of 620 feet per minute (ft/min) rate of climb at sea level (38 percent decrease) and a decrease in service ceiling of 3000 feet (19 percent decrease). Additionally, the airspeed for maximum rate of climb ($V_{max\ R/C}$) changed significantly between the MULTEWS and clean configurations. Figure 2 presents the optimum climb airspeed schedule for both configurations and at sea level, shows 65 KCAS for the clean configuration and 40 KCAS for the MULTEWS at $V_{max\ R/C}$. The operator's manual should be changed to reflect the climb performance and climb schedule for the MULTEWS configured aircraft.

Level Flight Performance

10. The level flight performance of the MULTEWS configured UH-1H was evaluated at the general conditions listed in table 1 to determine power required and fuel flow as a function of airspeed. Specific range, long-range cruise airspeed, endurance airspeed, and engine performance characteristics were also determined. Level flight tests were also made in the clean configuration (external MULTEWS antennas removed) to provide a base line for performance comparisons.

11. All level flight performance was at zero sideslip, using the constant gross weight to air pressure ratio (W/δ) and constant main rotor speed to the square root of temperature ratio ($N/\sqrt{\theta}$) technique. The test techniques and data analysis methods used are described in appendix D. The results of these tests are presented in appendix E, nondimensionally in figures 5 through 8, and dimensionally in figures 9 through 18. Aircraft specific range, long range cruise airspeed, and maximum endurance are summarized in figures 19 through 22.

12. Figure A presents a representative comparison of level flight power available and required for the MULTEWS and clean configurations. Maximum continuous power available at 80 knots true airspeed (KTAS) in the MULTEWS configuration is 100 shaft horsepower (shp) less (10 percent decrease) than is available in the clean configuration due to the engine bleed air required for MULTEWS systems. The MULTEWS has a significant increase in power required for level flight. At 80 KTAS the increase is 186 shp (31 percent increase). The equivalent flat plate area (propulsive efficiency assumed unity) of the MULTEWS configurations was found to be 43 ft^2 (equation 11, app D) greater than the clean UH-1H helicopter which was found to be 27 ft^2 (equation 10, app D). The airspeed for minimum power required shifted from 68 KTAS in the clean configuration to 55 KTAS in the MULTEWS configuration. Range and endurance of the UH-1H in the MULTEWS configuration were substantially reduced, as shown by the comparison of figures 19 through 22, appendix E. The level flight performance results are summarized in table 3. The operator's manual should reflect the changes in performance.

Autorotational Descent Performance

13. The autorotational descent performance of the MULTEWS configured UH-1H was evaluated at the general conditions listed in table 1. Additional flights in the clean configuration were performed for a base-line comparison. The test techniques and data analysis methods used for this test are described in appendix D. The results of this test are presented in figure 23, appendix E.

14. The addition of MULTEWS equipment to the clean UH-1H caused the minimum rate of descent to increase from 1725 ft/min to 2085 ft/min (21% increase). The airspeed for minimum rate of descent changed from 68 KCAS clean to 59 KCAS for the MULTEWS. The airspeed for best glide also changed from 85 KCAS clean to 78 KCAS for MULTEWS. Best glide ratio was degraded from 4.34:1 to 3.02:1 (30% decrease). The operator's manual should reflect the change in autorotational performance.

FIGURE A
MULTEWS LEVEL FLIGHT PERFORMANCE COMPARISON
JUH-1H USA S/N 74-22338
REFERRED ROTOR SPEED = 318 RPM
ALTITUDE = 5000 FEET
STANDARD DAY
GROSS WEIGHT = 9200 LB
NOTES: 1. POWER REQUIRED DATA DERIVED FROM FIGURES 5 THROUGH 8, APP E
2. POWER AVAILABLE DATA OBTAINED FROM FIGURES 93 THROUGH 96, APP E

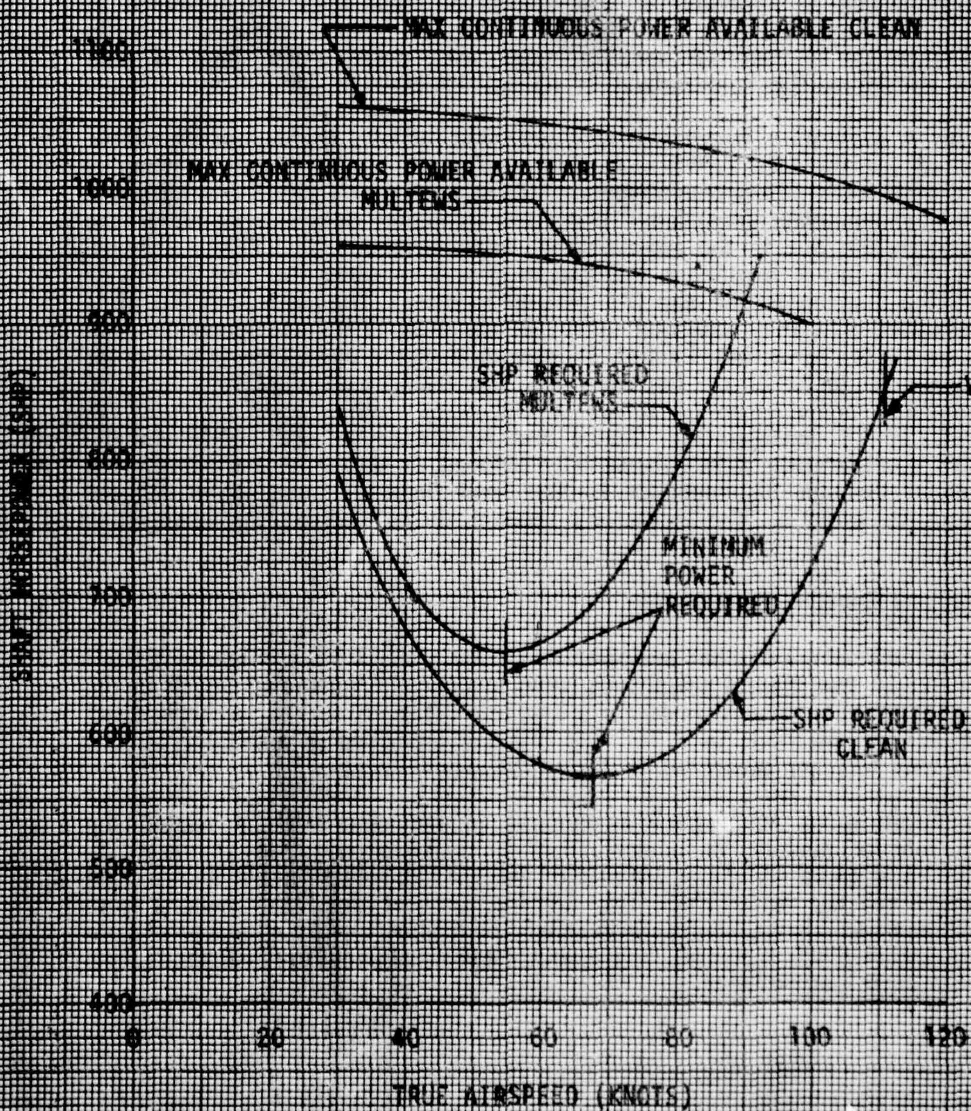


Table 3. Summary of Recommended Airspeeds, Range, and Endurance.[1]

Condition	Configuration		Percent Degradation
	Clean	MULTEWS	
Airspeed for minimum power required (KTAS)	68	55	19
Airspeed for maximum endurance[2] (KTAS)	70	58	17
Recommended cruise airspeed (KTAS)	111	91	18
Fuel flow for maximum endurance (lb/hr)	465	525	13
Specific range (NAMPP)[3]	0.188	0.143	24
Maximum endurance[4] (hr)	2.72	2.41	11
Maximum range[4] (nautical miles)	241	183	24

[1]Based on takeoff gross weight 9200 lbs, 5000 ft, standard day, 324 rpm.
[2]Based on minimum fuel flow.
[3]NAMPP: Nautical air miles per pound of fuel.
[4]Based on 209.5 gallon crashworthy fuel system at 6.5 lb/gallon with 10% reserve and an average gross weight of 8587 lb.

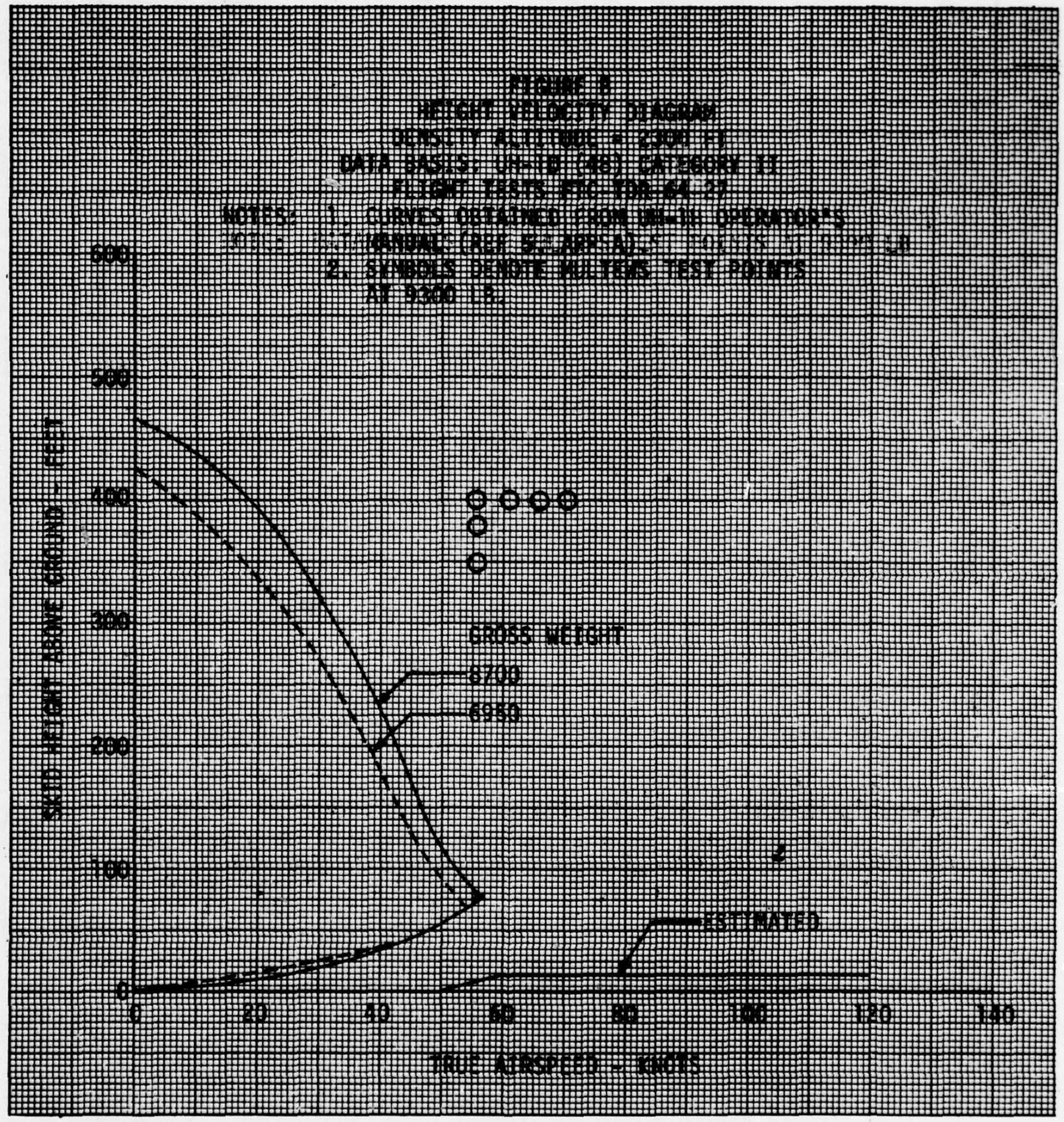


FIGURE 8
HEIGHT VELOCITY DIAGRAM
DENSITY ALTITUDE = 2300 FT
DATA BASIS: UH-1D (48) CATEGORY II
FLIGHT TESTS FTC TDR 64-27
NOTES: 1. CURVES OBTAINED FROM UH-1H OPERATOR'S
MANUAL (REF 5, APP A)
2. SYMBOLS DENOTE MULTEWS TEST POINTS
AT 9300 LB.
SKID HEIGHT ABOVE GROUND - FEET
600
500
400
300
200
100
0
GROSS WEIGHT
6700
6950
ESTIMATED
0
20
40
60
80
100
120
140
TRUE AIRSPEED - KNOTS

Height-Velocity Performance

15. The significant change in autorotational performance, combined with the degradation in autorotational handling qualities (discussed in para 24), led to a limited H-V evaluation being added to the original test program. The H-V evaluation of the MULTEWS configuration was conducted to determine if safe autorotational landings could be accomplished at 9300 lb gross weight, 50 KIAS, and 200 ft AGL since there is an operational requirement to operate no higher than 200 ft AGL for survivability reasons, if possible. A build-up program was conducted as described in appendix D. Three significant time histories of the H-V evaluation are presented in figures 24 through 26, appendix E.

16. A safe autorotational landing was performed at 9300 lb from 375 ft AGL and 50 KIAS entry airspeed (fig. 24, app E). An attempt was made to demonstrate a safe landing from the same entry airspeed and gross weight from 350 ft AGL (fig. 25), which resulted in major damage to the aircraft. Analysis of figure 24 (entry from 375 ft) shows a 1/2-inch aft longitudinal control input as the collective pitch was lowered; this combination resulted in a nose down pitch of 14° and a 4000-ft/min maximum rate of descent. Analysis of figure 25 (entry from 350 ft) shows the longitudinal control held fixed as the collective pitch was lowered, resulting in a 16° nose-down pitch and 4300-ft/min rate of descent. These data show an increase of 300 ft/min rate of descent for 2° more nose-down pitch. In both cases the target airspeed of 60 KIAS was reached. Qualitatively, the pilot is unable to distinguish precisely the nose-down pitch attitude. Use of the aircraft pitch attitude indicator is impracticable because of the heavy demands on the pilot when maneuvering the aircraft into the proper landing attitude while descending at 4000 ft/min. Consistent H-V performance in the MULTEWS configuration is very sensitive to relatively minor changes in pilot technique.

17. The changes in pitch attitude, rotor speed, and collective position shown in figure 26, appendix E, are typical of all safe autorotational landings. These data show that rotor speed increased rapidly during the landing deceleration and required a collective pitch application 1.5 seconds after initiating the deceleration to prevent a rotor overspeed. Typical rotor speed was 335 rpm, 2.5 seconds after commencing the deceleration. Extensive pilot compensation (HQRS 6) was required to maintain rotor speed within operational limits during the deceleration. Peak nose-up pitch attitude was 18° followed by lowering the aircraft to 12° nose up just before touchdown, resulting in touchdown ground speeds of approximately 30 knots and 3.5 ft/min rate of sink. Qualitatively, lesser touchdown speeds will require greater nose-up pitch attitudes, and the probability exists that the rotor will overspeed due to the pilot's attention being directed to outside references. The extensive pilot compensation required to maintain rotor speed within operational limits during decelerations is a shortcoming at the MULTEWS mission gross weight.

18. Figure B shows the H-V diagram presented in the operator's manual for the UH-1H and the height and velocity test conditions at 9300 lb gross weight during this evaluation. Within the scope of this test, the H-V diagram presented in the operator's manual for the UH-1H does not accurately identify combinations of height and velocity from which the MULTEWS configuration can be safely landed following a sudden engine failure.

HANDLING QUALITIES

General

19. The installation of MULTEWS system and equipment on the UH-1H resulted in a degradation in handling qualities. Three deficiencies were noted: high 1-per-rotor-revolution (1/rev) vibrations in autorotations at airspeeds greater than 60 KCAS, high one-half/rev vibrations in maximum performance climbing flight, and the loss of directional control in right sideward flight at mission gross weight. Weak static longitudinal stability in level flight and the nonlinear longitudinal control position gradients in climbs and autorotations, combined with unsatisfactory lateral-directional stability characteristics, make precise trim and airspeed control difficult and are shortcomings. The combination of high mission gross weight and marginal engine power available caused poor hover taxi characteristics. High vertical fin and horizontal stabilizer structural loads were encountered in all forward flight regimes above 60 KCAS.

Control System Characteristics

20. The mechanical characteristics of the control system were evaluated on the ground with the rotor and engine stopped. Hydraulic and electrical power were provided by external sources. A description of the test technique used is included in appendix D. Longitudinal, lateral, and directional control system characteristics are presented in figures 27 through 30, appendix E. Control system characteristics in flight were essentially the same as those observed under the static test conditions described above.

21. Table 4 presents a summary of control system characteristics. No excessive free play or trim control displacement band was noted in the control system. All the requirements of MIL-H-8501A were met except for the left directional breakout force which was 1.5 lb, instead of the required 3.0 to 7.0 lb in paragraph 3.3.13 of MIL-H-8501A. The discontinuity in directional breakout force and the relatively low directional force gradient were not apparent to the pilot in flight.

Control Positions in Trimmed Forward Flight

22. Control positions in trimmed forward flight were evaluated in conjunction with level flight performance tests at the general conditions listed in table 1. Test data are presented in figures 31 through 34, appendix E, for both the MULTEWS and clean configurations.

23. Comparing figures 31 and 33, appendix E, shows the difference in pitch attitude and the control positions in trimmed forward flight between the clean and MULTEWS configurations. Below 40 knots calibrated airspeed (KCAS), there is very little difference between the two configurations; however, at 80 KCAS in level flight, the MULTEWS required 4 degrees more nose-down pitch attitude than the clean configuration. The differences in collective, pedal, and lateral controls at the higher airspeeds are largely a function of the higher drag in the MULTEWS configuration and the corresponding higher power requirements. The control position characteristics of the MULTEWS equipped UH-1H in trimmed forward flight are satisfactory.

Table 4. Control System Characteristics Summary[1]

Test Parameter	Control System[2]		
	Longitudinal	Lateral	Directional
Free play (in.)	0.0	0.0	0.0
Trim control displacement band (in.)	0.4	0.2	0.6
Breakout force (incl friction) (lb)	Fwd 0.7	Left 0.7	Left 1.5
	Aft 1.1	Right 0.5	Right 3.0
Average friction band (lb)	Fwd 1.3	Left 0.7	Left 4.2
	Aft 1.0	Right 0.6	Right 3.0
Average force gradient (lb/in.)	Fwd 1.0	Left 1.0	Left 6.4
	Aft 1.5	Right 0.8	Right 6.4
Full control travel (in.)	12.3	12.6	6.7

[1]Ground test data. External electric and hydraulic power engine rotor stopped. Cyclic and collective friction off. Force trim on.
[2]Collective not measured.

Static Longitudinal Stability

24. The static longitudinal stability characteristics were evaluated with collective fixed at the trim conditions shown in table 2 for both mid and aft cg locations. The flight test techniques and data analysis methods used are described in appendix D. These evaluations were made in both the clean and MULTEWS configurations. Test data are presented in figures 35 through 49, appendix E.

25. The MULTEWS configuration significantly reduced the static longitudinal stability of the UH-1H helicopter. Changing cg location from mid to aft cg further reduced the static longitudinal stability. In level flight the longitudinal control position gradients indicated weak but positive stability regardless of cg location, configuration, or trim airspeed. Figure C shows a comparison of longitudinal control position and pitch attitude between the clean and MULTEWS

configuration. There is both a reduction of static longitudinal stability and a significant increase in nose-down pitch attitude in the MULTEWS configuration. Moderate pilot compensation was required to maintain a precise airspeed (HQRS 4) in level flight. The longitudinal control position gradient for the clean configuration in maximum performance climbs indicated positive stability. However, in the MULTEWS configuration the longitudinal control position gradient was nonlinear with positive stability at airspeeds slower than trim and neutral to negative stability at airspeeds higher than trim. Figure D shows the comparison of longitudinal control position and pitch attitude between the clean and MULTEWS configurations. The nonlinear longitudinal control gradient appeared to the pilot as the effects of turbulence and required considerable pilot compensation (HQRS 5) to hold a precise airspeed in maximum performance climbs. The static longitudinal control gradient in autorotations at a trim airspeed of 60 KCAS for the MULTEWS configuration was discontinuous at trim with positive stability at airspeeds slower than trim and neutral at airspeeds faster than trim. However, at the higher trim airspeed of 84 KCAS, the static longitudinal stability improved. Considerable pilot compensation was required to maintain a precise airspeed (HQRS 5) in the MULTEWS configuration in autorotations. The unsatisfactory static longitudinal stability characteristics of the MULTEWS configuration is a shortcoming.

Static Lateral-Directional Stability

26. The static lateral-directional stability characteristics in the MULTEWS configuration were evaluated with collective fixed at the level flight trim conditions listed in table 2. The test techniques and data analysis methods used are described in appendix D. The variation of control position and roll attitude with stabilized incremental left and right sideslip angles is presented in figures 50 and 51, appendix E. Directional stability was strongly positive (left directional control required to maintain right sideslip and vice versa) with no discontinuities. Effective dihedral was also positive (right lateral control required to maintain right sideslip and vice versa). Side-force characteristics were also positive (variation of bank angle with sideslip) but extremely weak. An out of trim condition was not felt by the pilot until sideslip angles greater than 20 degrees left and right were reached at both trim airspeeds, which contributed to difficulties while attempting to maintain balanced flight (para 25) (HQRS 4). This weak side-force characteristic is a shortcoming.

Maneuvering Stability

27. The maneuvering stability characteristics in the MULTEWS configuration were evaluated by performing constant collective, constant airspeed turns at the conditions listed in table 2. The variation of longitudinal control position with normal acceleration is presented in figures 52 and 53, appendix E. The longitudinal control position gradient was positive (increasing aft cyclic required for increasing normal acceleration) at both airspeeds. Bank angle and airspeed were maintainable up to bank angles of 45 degrees left or right (HQRS 2). At bank angles in excess of 45 degrees, airspeed and bank angle could not be maintained within ±5 knots or ±5 degrees (HQRS 5). Since flight at high bank angles is not critical to the MULTEWS mission, within the scope of this test, the maneuvering stability characteristics of the MULTEWS configuration are satisfactory.

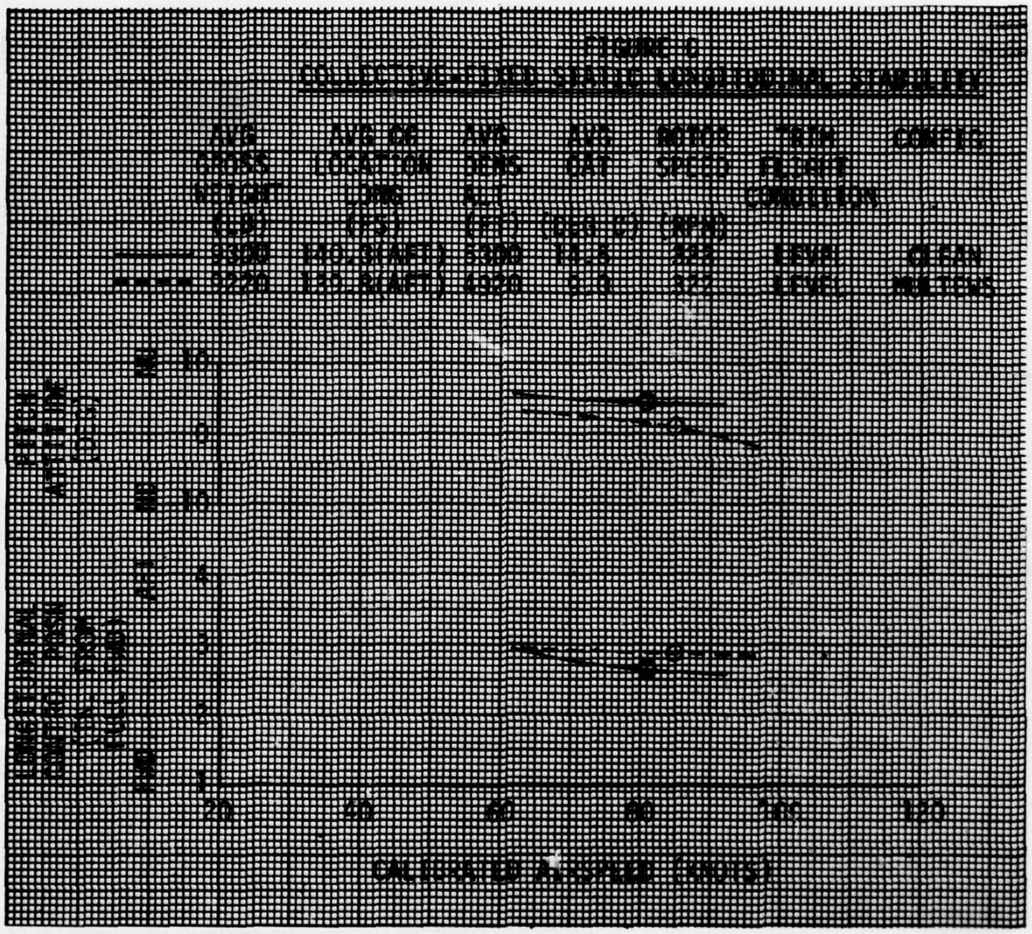
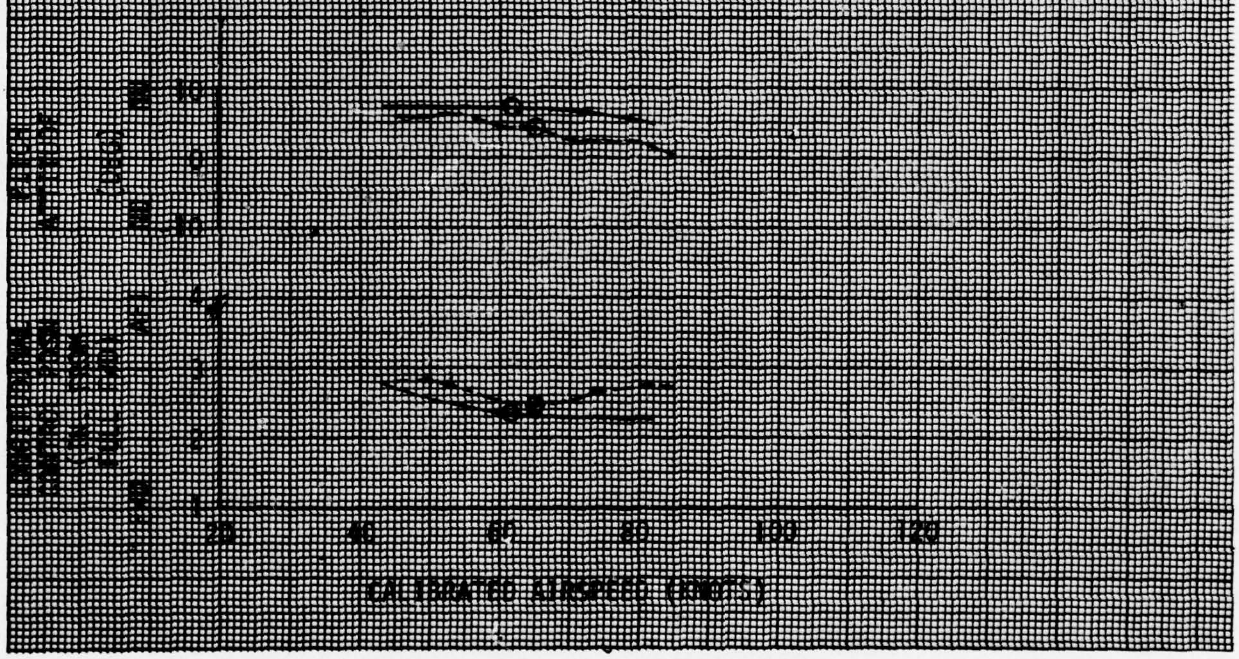


FIGURE 6
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
AVG GROSS WEIGHT (LB)
AVG CG LOCATION LONG (FS)
AVG DENS ALT (FT)
AVG OAT (DEG C)
ROTOR SPEED (RPM)
TRIM FLIGHT CONDITION
CONFIG
LEVEL
CLEAN
LEVEL
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

FIGURE 11

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
5200	140.0 (AFT)	7440	12.0	324	CLIMB	CLEAN
5020	139.1 (AFT)	6980	4.0	322	CLIMB	MITTENS



Dynamic Stability

28. The short-term dynamic stability characteristics in the MULTEWS configuration were evaluated at the level flight trim conditions listed in table 2. Test techniques and data analysis methods used are described in appendix D.

29. Aircraft short-term response following forward and aft longitudinal control pulse inputs was essentially deadbeat. Following left and right lateral and directional control inputs, the resulting short-term oscillations damped within three cycles. Figure 54, appendix E, shows a right lateral input. The short-term dynamic stability characteristics are satisfactory. The MULTEWS long-term response (figs. 55 and 56) at 60 KCAS was oscillatory and lightly damped with a period of 53 seconds and damping ratio of .076. At a trim airspeed of 80 KCAS the aircraft slowly diverged nose down and recovery was required to prevent exceeding the never-exceed airspeed (V_{NE}). The divergence was easily controlled by the pilot (HQRS 3). The long-term dynamic longitudinal stability characteristics are satisfactory.

30. The Dutch roll and spiral stability characteristics in the MULTEWS configuration were evaluated at 60 and 80 KCAS trim airspeeds. The spiral stability was slowly convergent in a right bank and neutral in a left bank. In calm air, following releases from steady-heading sideslip (fig. 57, app E), the Dutch roll oscillations damped within two cycles. However, these oscillations were easily excited by small lateral or directional control inputs and were continously excited in light turbulence such that they appeared to be undamped. The Dutch roll oscillation was a nuisance requiring continuous small corrective inputs (HQRS 4). The easily excited Dutch roll oscillation is a shortcoming.

Low-Speed Flight Characteristics

31. The low-speed flight characteristics of the MULTEWS configured helicopter were evaluated at the general conditions listed in table 2. The test techniques and data analysis methods used are described in appendix D. The results of the test are presented in figures 58 and 59, appendix E.

32. The low-speed flight characteristics of the MULTEWS equipped UH-1H (clean and MULTEWS configuration) were evaluated qualitatively during taxiing to and from the takeoff point as an integral part of each flight. Due to the high mission gross weight of MULTEWS (9200 lbs), IGE hover required power settings near topping power. Operations near topping power resulted in lateral vibrations induced by the engine fuel control (para 50). A high pilot workload was required to maintain a stabilized hover with wind velocities from 5 to 15 knots in any quadrant. The combination of these characteristics made hovering the MULTEWS on a moderately windy day a relatively high pilot workload task (HQRS 6) when turning downwind and crosswind. The increase in pilot effort, plus the marginal engine power available, which often resulted in rotor droop and settling to the ground, resulted in handling qualities problems when operating at density altitudes of 3000 ft and above. The poor hover taxi characteristics of the UH-1H high mission gross weights are a shortcoming.

33. At the high mission gross weight (9200 lbs) required for the MULTEWS mission and at the test site density altitude (3000 ft), topping power was often

required for hover, and any further increase in power required, as in turning downwind or crosswind or accelerating in any direction from a hover, resulted in rotor speed droop and aircraft settling. Pilot effort required to hold stabilized points was indicative of the workload when hovering in various wind conditions, and emphasized potential mission accomplishment problems during ground operations at density altitudes above 3000 ft, and substantiated the difficulties encountered during hover taxi. During acceleration in right sideward flight at 10 to 15 KTAS, insufficient left pedal remained, and directional control was lost. This loss of directional control in right sideward flight was previously documented in USAASTA Report No. 66-04 (ref 7, app A) as a deficiency, and remains a deficiency at the MULTEWS mission gross weight.

Instrument Flight Capability

34. Simulated instrument meteorological condition (IMC) flight characteristics were evaluated in the MULTEWS configuration at an aft cg. The specific tasks evaluated were instrument takeoff (ITO); ability to maintain airspeed, altitude, and heading; and automatic direction finding (ADF) tracking, holding, and approach. IMC flight was simulated by covering the pilot windshield, chin bubble, and door, and flying with sole reference to the aircraft's flight and navigational instruments. (Note: the MULTEWS configuration does not include VOR navigation capability.)

35. Increased attention was required to maintain a takeoff attitude that would establish a positive rate of climb and to increase airspeed smoothly to $V_{max\ R/C}$ during the ITO task. The high gross weight of the MULTEWS configuration precluded a crisp departure from the ground and the poor static longitudinal stability characteristics resulted in the pilot overcontrolling the aircraft longitudinally. The combination of these two characteristics gave a stairstep appearance when the ITO was viewed in profile. Considerable pilot compensation (HQRS 5) was required to execute the ITO maneuver.

36. The pilot's ability to maintain airspeed, altitude, heading, and track using ADF navigation was qualitatively evaluated in two parts at 75 KIAS. Part 1 was an evaluation of the pilot's ability to maintain a performance standard of ±2 knots, altitude ±20 feet, and heading ±5 degrees. Then using the degree of pilot compensation identified in part 1, the ADF tracking task was added to the pilot workload, and the effect on the performance standard noted. The evaluation was made in smooth air and moderate pilot compensation (HQRS 4) was required to obtain the performance standards stated. Adding the tracking task (part 2) and continuing to use moderate pilot compensation resulted in a ±5 knot airspeed variation. This characteristic is attributed to the reduced static longitudinal stability of the MULTEWS configuration.

37. The pilot's ability to enter a holding pattern over a nondirectional beacon (NDB), hold over a NDB, and execute an ADF approach was qualitatively evaluated in light turbulence at 60 KIAS. Published standard procedures were used to perform these three tasks. All three tasks required considerable pilot compensation (HQRS 5), primarily due to the reduced longitudinal stability. Airspeed excursions of ±5 knots from trim required the pilot to devote more than normal effort to airspeed control. More accurate airspeed control was possible; however, it was at the expense of maintaining the published in-bound track, commencing the descent at the proper time, and giving the appropriate position report in a timely manner.

Yaw oscillations caused by gusts were easily excited. Qualitatively, the MULTEWS can be flown in IMC; however, pilot workload is higher than that of the clean configuration UH-1H aircraft. In view of the higher pilot workload, IMC flight in the MULTEWS configuration should be limited to missions of tactical necessity.

AIRCRAFT SYSTEMS FAILURES

Simulated Engine Failures

38. Simulated engine failures were evaluated in the MULTEWS configuration at the conditions listed in table 2. The test techniques and data analysis methods used are described in appendix D. Figures 60 and 61, appendix E, present time histories of the simulated engine failure, aircraft response, and subsequent aircraft recovery. The requirements of paragraph 3.5.5.1 of MIL-H-8501A were not met in the yaw axis, in that 10 degrees of roll and yaw were exceeded within 2 seconds; however, the requirements of the specification were met in the other axis. Simulated engine failure characteristics of the MULTEWS equipped helicopter are satisfactory.

STRUCTURAL DYNAMICS

Vibration Characteristics

39. Vibration characteristics were qualitatively and quantitatively evaluated throughout the test program. Vibration data were gathered simultaneously with data from other tests, with particular emphasis placed on the data recorded during level flight, climbs, and autorotation. During climbs at or near topping power and during autorotations, moderate to severe lateral vibrations were felt by the crew, and observers in the chase aircraft were able to perceive vibration motion on the horizontal stabilizer and vertical fin. As a result, additional instrumentation was installed at the locations specified in appendix C to quantitatively evaluate the vibrations. The vibration characteristics of the test aircraft were adversely affected by the installation of the external MULTEWS antennas.

40. Representative vibration data obtained in level flight are presented in figures 62 through 69, appendix E. In level flight the vibrations in the MULTEWS configuration were equal to or greater than at comparable conditions in the clean configuration. The one-half/rev vibrations increased with airspeed and were objectionable to the crew (VRS 6) at airspeeds greater than 75 KCAS in the MULTEWS configuration. The vibration levels for the main rotor harmonics on figures 62 through 64 are averaged over 5 seconds and do not reflect the maximum felt by the crew. The one-half/rev has a periodic increase and decrease (*ie*, "beat"), as shown in figure 70. The 6/rev vibration limits set by MIL-H-8501A, paragraph 2.7.1b, were exceeded at the pilot floor longitudinal, cg floor vertical, and cg floor longitudinal positions and were objectionable (VRS 4). The increased vibrations of the MULTEWS configured aircraft in level flight are a shortcoming.

41. During climbing flight with the T53-L-13B fuel control assembly at or near topping power, a moderate to severe lateral oscillation at one-half/rev was observed in both the MULTEWS and clean configured helicopter. Figure 70, appendix E, presents a comparison of these vibration characteristics. The one-half/rev vibration

was characterized by a "beat" or periodic increase and decrease at the 2.5 Hz primary frequency. This "beat" had a period of approximately 3 seconds. The one-half/rev lateral vibrations were objectionable during maximum performance climbs at all airspeeds (VRS 7). The one-half/rev lateral vibration increased in frequency of occurrence and magnitude from the clean to MULTEWS configuration. The high one-half/rev vibrations in maximum performance climbing flight are a deficiency.

42. During autorotational descents a severe lateral vibration was observed in the MULTEWS configuration. Figure 79, appendix E, represents a comparison of the clean and MULTEWS configured vibration characteristics. The 1/rev lateral vibrations were objectionable to the crew during autorotations at airspeeds greater than 60 KCAS (VRS 7). A significant increase in lateral vibration at the tail rotor gearbox was observed for the MULTEWS configuration. The character of this vibration was similar to that described in paragraph 41 for the climbs. The high 1/rev vibrations in autorotations at airspeeds greater than 60 KCAS are a deficiency in the MULTEWS configuration.

Structural Loads

43. The high vibration levels (para 39) caused a concern for the structural integrity of the tail boom and horizontal stabilizer. Tufting was added to the aircraft and high-speed film was employed to obtain qualitative flow visualization. Photo B shows the clean-configured helicopter in level flight at 80 KCAS and tufts show undisturbed airflow over the fuselage aft body and the tail boom. Photo C shows the MULTEWS configured aircraft at the same conditions; however, tufts show turbulent airflow over the aft body and tail boom. As a result of these observations, strain gauge instrumentation was installed at the locations specified in the modified Airworthiness Release and is listed in appendix C. Flight loads data were monitored in real time during all subsequent tests and a load cycle counting procedure was implemented to determine component life reduction caused by damaging loads. In the clean configuration all flight loads were satisfactory except in high power climbing flight at airspeeds greater than 60 KCAS; the resultant oscillatory beamwise bending exceeded the endurance limit of the horizontal stabilizer spar. In the MULTEWS configuration, the endurance limit of the horizontal stabilizer spar was exceeded in level flight at airspeeds above 75 KCAS, in climbing flight at airspeeds above 60 KCAS, and in autorotation at airspeeds greater than 40 KCAS. The endurance limit of the vertical stabilizer spar cap was exceeded in autorotations at airspeeds greater than 40 KCAS. The MULTEWS installation caused high structural loads in the horizontal stabilizer spar and the vertical stabilizer spar cap.

RELIABILITY AND MAINTAINABILITY

44. The addition of the MULTEWS equipment to the UH-1H airframe resulted in partial or total blockage of two maintenance-related areas. The "Hell Hole," located on the underside of the aircraft, is the primary access area to the bottom of the transmission, left links, flight control servos, and main structural areas of the airframe, and is required to be inspected visually as part of the daily inspection. This area is blocked by the doppler navigation antennas and rectifiers. Also, the transmission access panels are blocked by the radio equipment racks (photo D). Access to these panels is also required as a part of each daily inspection of the transmission mounts, transmission dampers, flight control actuators, and general

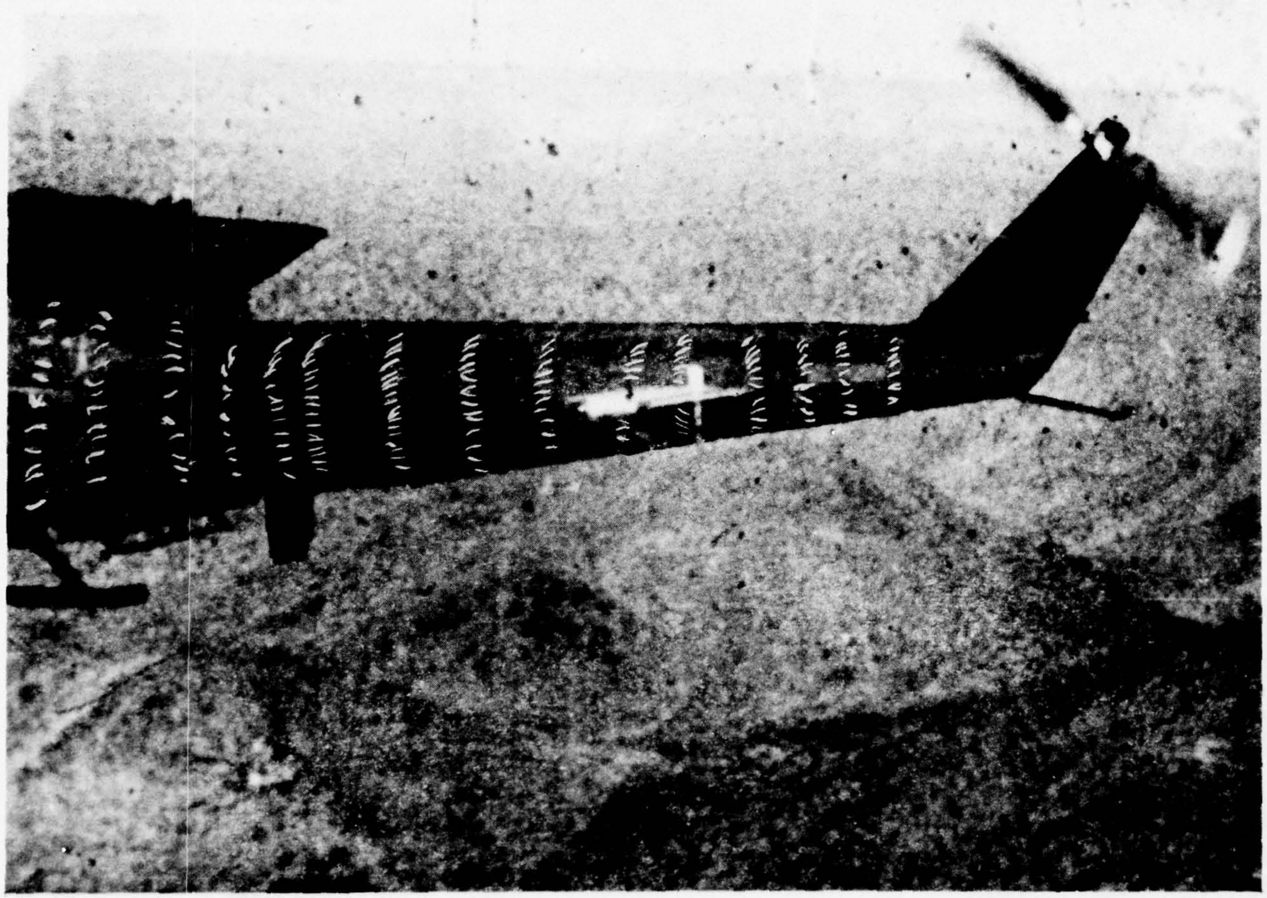


Photo B. Tufting at 80 Knots, Clean Configuration.

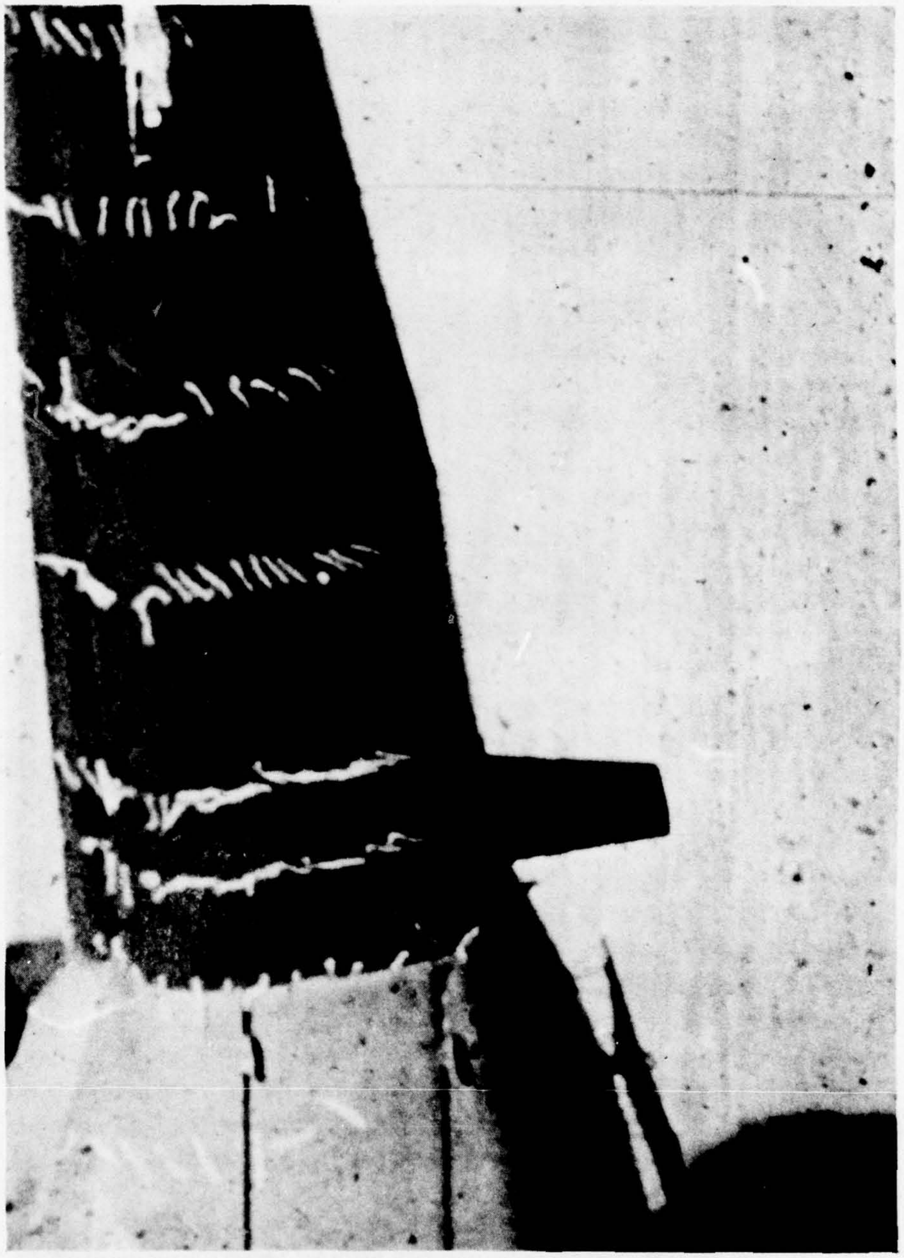


Photo C. Tufting at 80 Knots, MULTEWS Configuration.

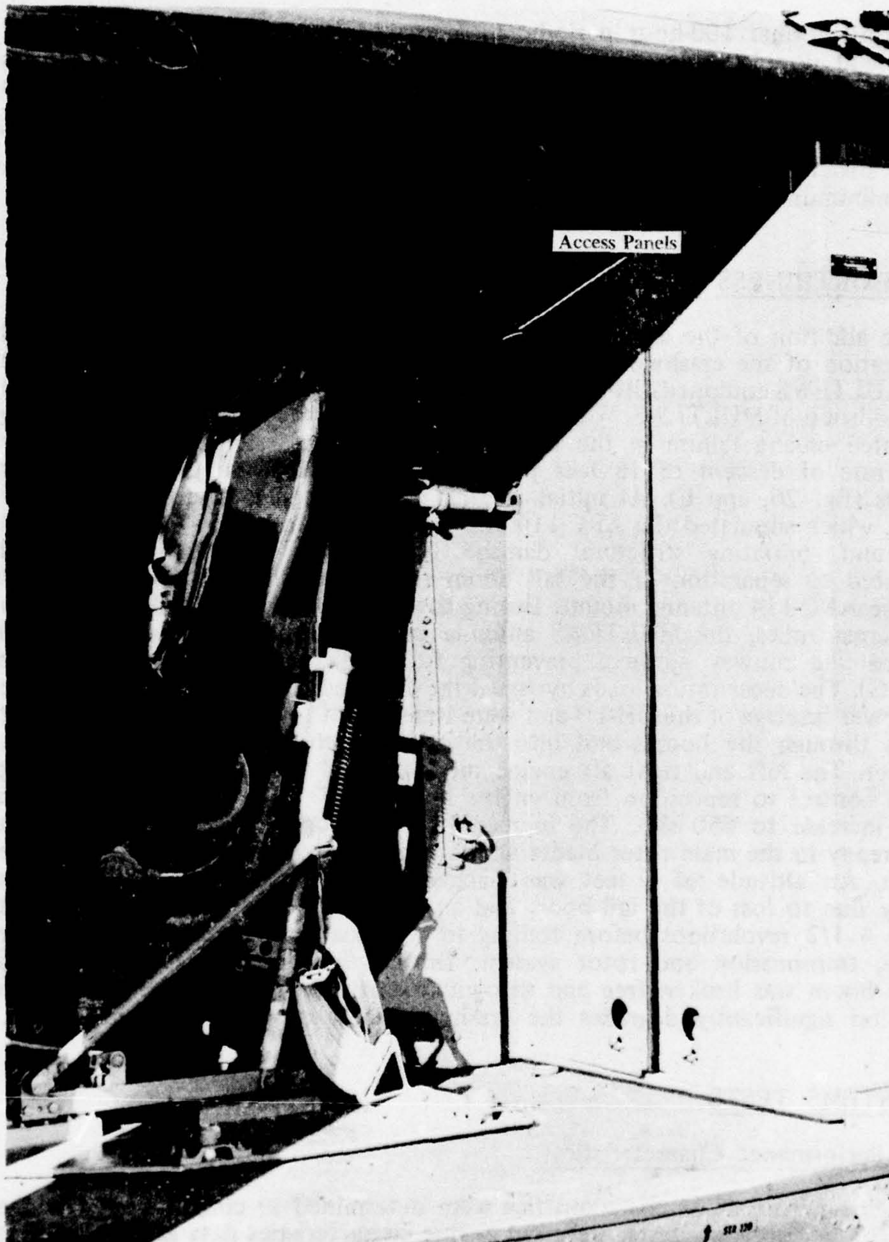


Photo D. Left side of JUH-1H Showing Blockage of Transmission Access Panels by MULTEWS

structural integrity. Minor panel modifications were made, and by use of mirrors, the daily inspections can be accomplished at the cost of approximately 1 hour additional total time on the daily inspection.

45. During normal 100-hour periodic maintenance, the entire radio equipment cabinets and doppler antennas must be removed for proper access. The cabinets were not designed for easy removal, and the lack of quick disconnect features on the wires requires at least 15 manhours for removal of each of the two cabinet assemblies. The radio cabinets should be redesigned to slide out after removal of required structural fasteners, and all wiring should be integrated into one harness with a minimum number of quick disconnects.

CRASHWORTHINESS

46. The addition of the MULTEWS system and equipment to the UH-1H caused a degradation of the crashworthiness of the UH-1H. During H-V testing (para 15) of the MULTEWS equipped UH-1H, a major accident occurred which was aggravated by the addition of MULTEWS. While attempting an autorotational landing following a simulated engine failure in the H-V test, the helicopter impacted the runway with a rate of descent of 18 feet per second and a forward ground speed of 49 knots (fig. 26, app E). At initial impact, a semifrangible (styrofoam) dummy antenna, which simulated the ARC-114 antenna position for the H-V test, impacted the ground, initiating structural damage to the tail boom (photo E), and contributed to separation of the tail boom from the helicopter (photo F) just aft of the ARC-114 antenna mount. During the accident, prior to full deformation of the cross tubes, the MULTEWS antenna boom mounting bracket hardpoints contacted the runway surface, preventing full crash attenuation by the skids (photo G). The deceleration loads bypassed the designed crash attenuation structure of the lower fuselage of the UH-1H and were transmitted from the boom attachment brackets through the booms and into the main structural floor members of the helicopter. The left and right aft engine mounts failed (photos H and I), causing the fuel control to reposition from engine idle to 86% and the engine output to rapidly increase to 650 shp. The increased power, together with the maximum pitch already in the main rotor blades at the time, caused the helicopter to become airborne. An altitude of 5 feet was reached and the helicopter began to spin violently due to loss of the tail boom and antitorque system. The helicopter went through 4 1/2 revolutions before coming to rest, sustaining major damage to the airframe, transmission and rotor system. During the spin, the left MULTEWS antenna boom was broken free and thrown from the helicopter. The MULTEWS installation significantly degrades the crashworthiness of the UH-1H helicopter.

SUBSYSTEMS TESTS

Engine Performance Characteristics

47. Engine performance characteristics were determined in conjunction with the level flight performance tests. Referred engine characteristics data gathered during these tests and the data from the engine acceptance test (green run) are presented in figures 88 through 92, appendix E. Lycoming Program File No. AE 03.00.25.00 was used to determine power available and fuel flow data of the T53-L-13B engine (ref 8, app A). Engine shp available is shown in figures 93 through 96.

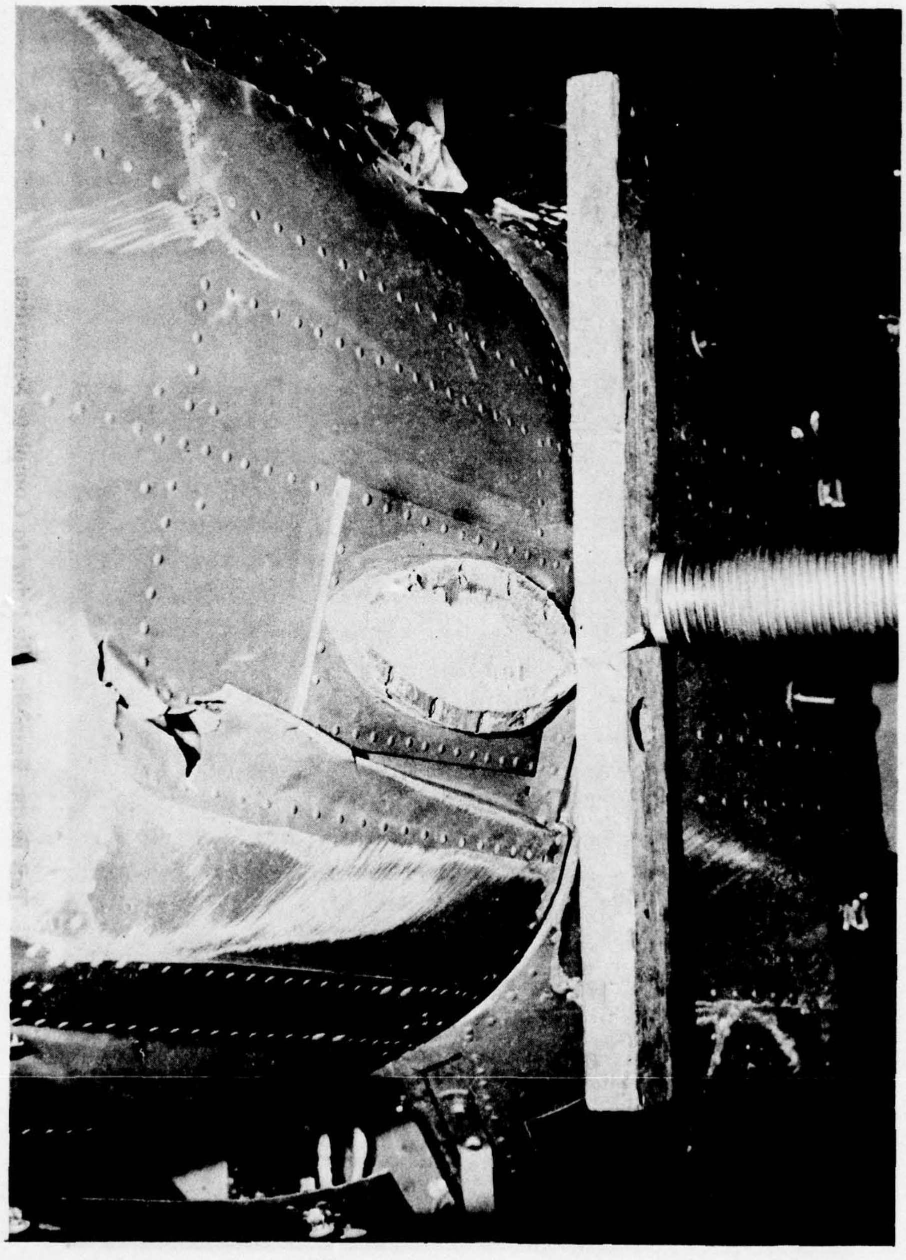


Photo E. Structural Damage to Tail Boom at Dummy ARC-114 Location.

Photo F. Tail Boom Immediately Prior to Complete Separation.

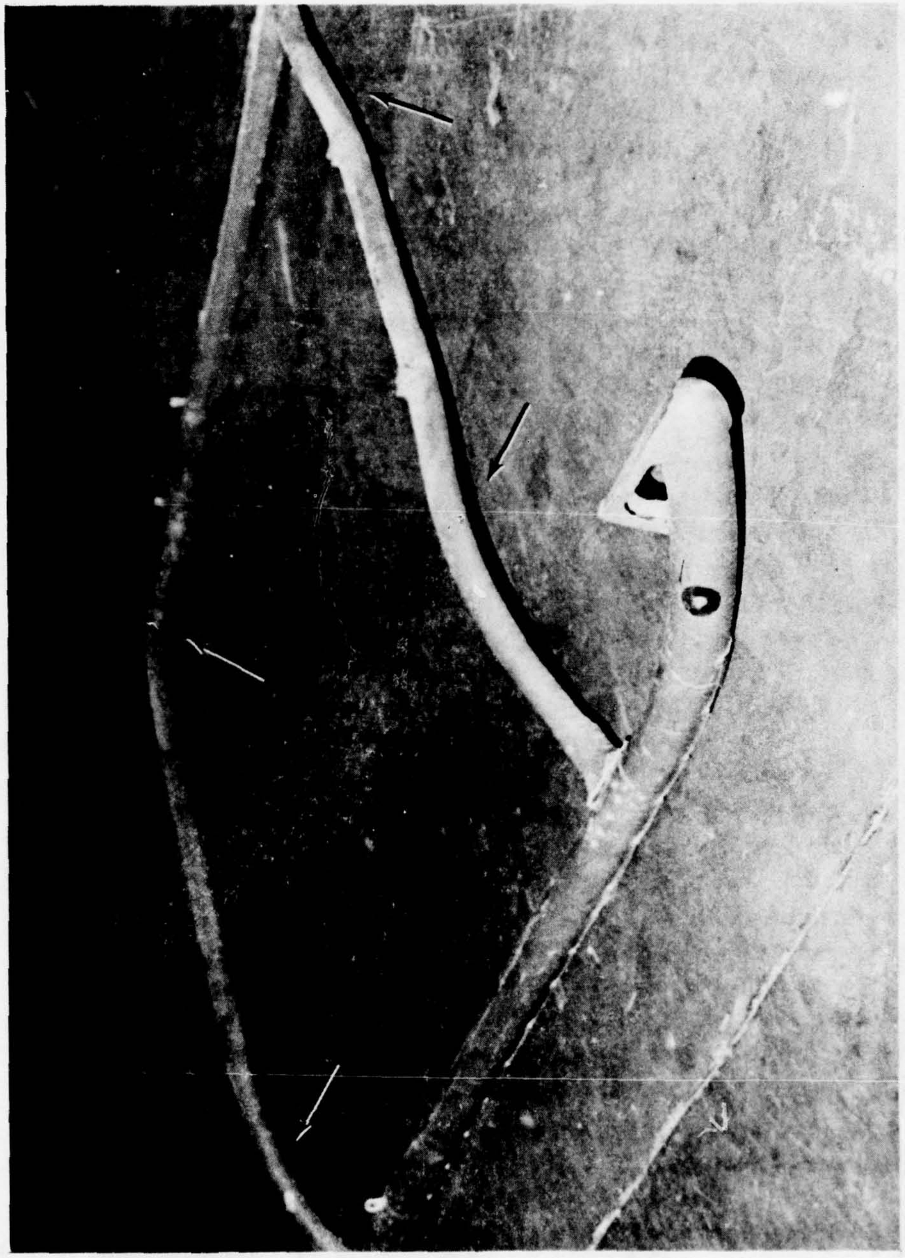


Photo G. JUH-1H Skid Assembly Indicating Deformation of Skids.

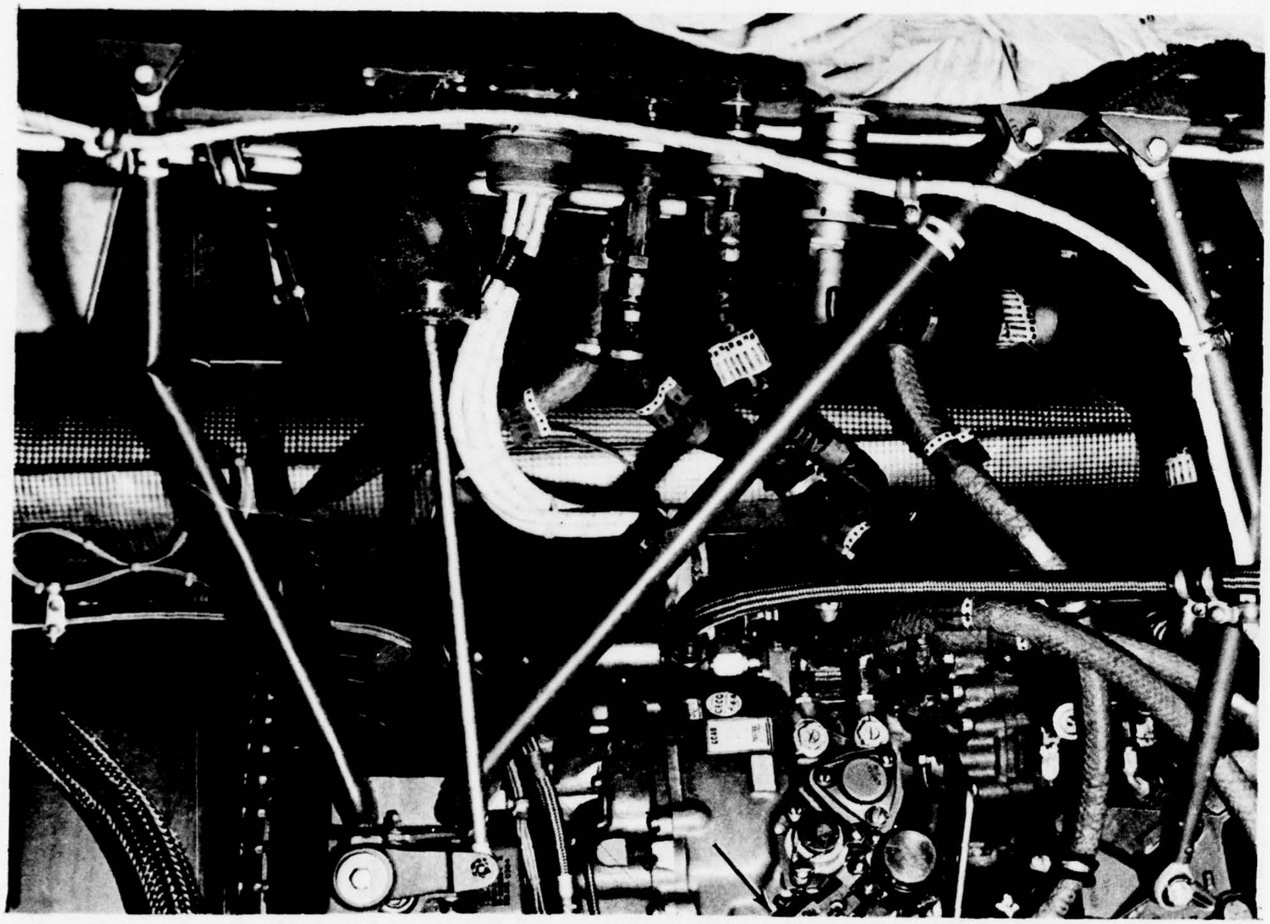


Photo H. Left Engine Deck, Deformed Engine Mount and Fuel Control.

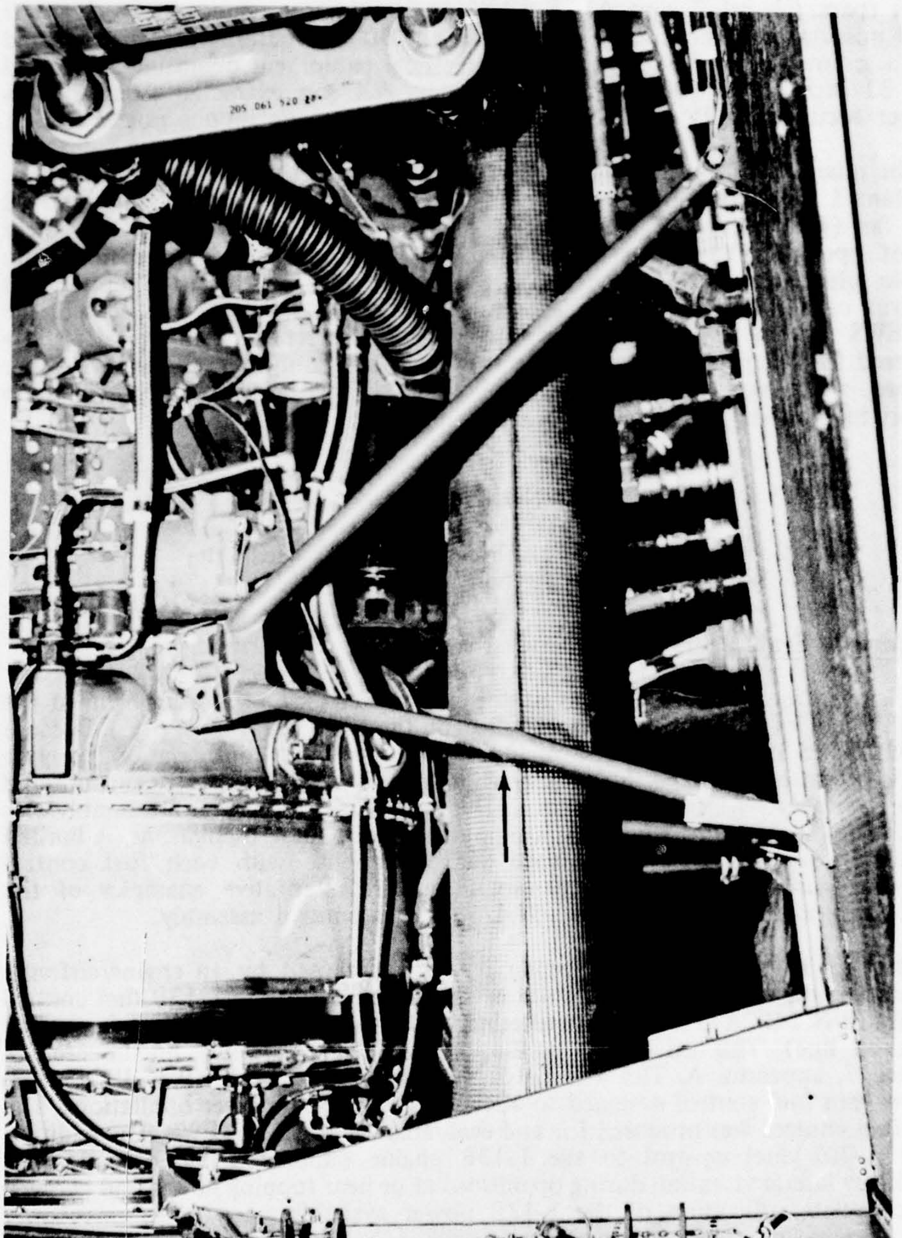


Photo I. Right Side Engine Deck, Deformed Engine Mount.

48. The power extracted from the gas producer section by the starter/generator of an unmodified UH-1H is 0.4 shp (para 63, ref 7, app A). In the MULTEWS configured UH-1H the starter/generator requires 8.4 shp for the aircraft electrical systems (para 63, ref 7, app A). A 30-KVA alternator provides electrical power for the mission equipment. The power from the 30-KVA alternator was measured during a ground run at 324 rpm with all electrical equipment operating and found to be 22 shp. On a 5000-foot standard day, 8.4 shp extracted from the gas producer section results in a 15-shp loss in maximum continuous power (MCP).

49. The quantity of bleed air used was not measured during these tests. However, a constant 1.15 percent of the total airflow to run the fuel boost pump and oil cooler fan (para 61, ref 7, app A) was used when the MULTEWS ECU system was not operated. When the MULTEWS ECU system was used the maximum available bleed air of 4 percent of the total airflow was used. Simultaneous operation of the engine anti-ice and the MULTEWS ECU system caused the MULTEWS system to fault. With anti-ice ON, 0.5 percent of the total airflow is diverted to the engine inlet anti-icing system, leaving only 3.5 percent for other functions, which was inadequate. The following NOTE should be included in the appropriate sections of the operator's manual:

NOTE

Operation of the engine anti-ice system will cause the MULTEWS ECU system to fault.

Fuel Control Evaluation

50. Engine torque and oscillations at topping power have been a problem of the T53-L-13B engine since it was first installed on the UH-1H (ref 7, app A). Because the MULTEWS configuration is a high-drag, heavy weight configuration, topping power is often required and the engine oscillations are more frequently encountered than with other UH-1H configurations. The T53-L-703 fuel control assembly was installed on the test aircraft in an attempt to reduce these oscillations. A limited evaluation was conducted to evaluate engine response with each fuel control installed. Figures 97 and 98, appendix E, are representative examples of the oscillations encountered with the T53-L-13B fuel control assembly.

51. The 2.5 Hz vibrations at topping power are caused by an engine/airframe torsional incompatibility which results in the engine with T53-L-13B fuel control assembly (P/N 2400A7) installed oscillating the drive train at its natural frequency (engine on line). This drive train oscillation had been previously documented in reference 7, appendix A. The T53-L-703 fuel control assembly (P/N 100770A3) is a low gain fuel control designed to alleviate the topping power oscillations. The L-703 fuel control was procured for and evaluated on the MULTEWS. The addition of the L-703 fuel control to the L-13B engine eliminated the objectionable one-half/rev lateral vibration during operations at or near topping power and allowed more complete utilization of the L-13B power available.

52. The evaluation with each fuel control included engine topping checks, collective oscillations, jump takeoffs, and collective pulls from low-power descents. The L-703 fuel control eliminated the oscillations at topping power (fig. 99,

app E). Collective oscillations at varying frequencies were made to check engine/drive train stability. All oscillations excited during these tests were well damped. Jump takeoffs and collective pulls from low power descents were conducted to evaluate static and transient rotor speed droop. Both these maneuvers were repeated several times by making collective step inputs at various rates to selected torque values. Collective pulls at a fast rate (less than 1 second) to high power settings caused the largest loss of rotor speed. The largest transient rotor speed loss was 19.5 rpm with the L-13B fuel control (fig. 100) and 21 rpm with the L-703 fuel control (fig. 101). Maximum static droops were 9.5 rpm and 7.5 rpm for the L-13B and L-703 controls, respectively.

53. Static and transient rotor speed changes with power changes were excessive with either fuel control installed. The L-703 fuel control eliminates oscillations at topping power while not significantly degrading other aspects of engine/airframe compatibility. The L-703 fuel control should be installed on all MULTEWS configured UH-1H helicopters.

Ground Handling Wheels

54. Due to the installation of the MULTEWS antennas, the standard UH-1H ground handling wheels will not fit between the antenna boom and the ground. The Bell Helicopter Model 212 ground handling wheels were furnished as part of the MULTEWS system and worked satisfactorily. One failure occurred during the wheel usage while raising the aircraft, and an Equipment Performance Report (EPR) was submitted (app F). The failure occurred with the antenna booms removed, which precluded any injury to maintenance personnel; however, had the booms been in place, injury would probably have resulted. A modified handle was inserted over the existing handle, which removed the operator's hand from between the antenna boom and the wheel assembly while pumping the hydraulic cylinder. Photo J shows the modified handle with an arrow pointing to the hand position for an unmodified wheel and illustrates the potential danger to the operator. The modified handle should be used on all MULTEWS ground handling wheels.

Aircraft Pitot-Static System

55. The ship's airspeed system was calibrated in level flight by using a calibrated pace aircraft and also a trailing bomb for airspeed reference. Ship's airspeed calibration data are presented in figure 102, appendix E. There was a significant difference in position error of the ship's airspeed system at airspeeds higher than 40 KIAS in the MULTEWS configuration. The clean configuration was calibrated with and without the test boom system installed, and no difference in position error could be attributed to the boom. Because of the difference in airspeed calibration between the clean UH-1H and the MULTEWS configured UH-1H, the data presented in figure 102 should be included in the operator's manual for MULTEWS configured aircraft.

Photo J. Modified 212 Ground Handling Wheel.

CONCLUSIONS

GENERAL

56. The addition of the MULTEWS equipment to the UH-1H airframe caused a significant decrease in performance for all areas tested as well as a degradation in handling qualities. The MULTEWS installation also adversely changed the vibration characteristics of the UH-1H, increased structural loads in the horizontal and vertical stabilizer spars, increased the maintenance workload, and degraded the aircraft crashworthiness.

57. Specific conclusions are:

a. High vertical fin and horizontal stabilizer structural loads were encountered in all forward flight regimes above 60 KCAS (para 43).

b. At the MULTEWS mission gross weight, safe autorotational landings cannot be performed below 400 ft AGL at 50 KIAS (para 16).

c. The MULTEWS configuration degraded crashworthiness of the basic UH-1H helicopter.

d. *The installation of the MULTEWS systems and equipment* caused a significant degradation in performance (paras 9, 12 and 14).

e. Under instrument meterological conditions, a significantly higher pilot workload is required to fly the MULTEWS configured UH-1H than is required for a clean UH-1H (para 37).

f. The L-703 engine fuel control eliminated power train oscillations at topping power (para 52).

g. The addition of the MULTEWS system caused significant changes in the UH-1H pitot-static system position error (para 55).

h. The placement of the radio equipment cabinets increased the manhours required for daily and periodic maintenance (paras 44 and 45).

i. The engine inlet anti-ice system and the MULTEWS ECU system could not be operated simultaneously (para 49).

j. Three deficiencies, five shortcomings, and three items of specification noncompliance were noted.

DEFICIENCIES

58. The following deficiencies were identified and are listed in decreasing order of relative importance:

a. High 1/rev vibrations in autorotation at airspeeds greater than 60 KCAS (para 42).

b. High one-half/rev vibrations in maximum performance climbing flight (para 41).

c. Loss of directional control in right sideward flight at high gross weight (para 33).

SHORTCOMINGS

59. The following shortcomings were identified and are listed in decreasing order of relative importance:

a. The unsatisfactory collective-fixed static longitudinal stability of the MULTEWS configuration (para 25).

b. The high vibration levels in level flight of the MULTEWS configuration (para 40).

c. The poor hover taxi characteristics (paras 32 and 33).

d. The weak side-force characteristics (para 26).

e. The easily excited Dutch roll oscillation (para 30).

SPECIFICATION NONCOMPLIANCE

60. The MULTEWS configured UH-1H failed to meet the following requirements of military specification MIL-H-8501A:

a. Paragraph 3.3.13 - Left directional breakout force was less than 3 to 7 pounds (para 21).

b. Paragraph 3.5.5.1 - Yaw attitude changed in excess of 10 degrees in 2 seconds during simulated engine failures (para 38).

c. Para 3.7.lb - Vibrations at the pilot floor and cg floor locations exceeded limits (para 40).

RECOMMENDATIONS

61. The deficiencies should be corrected prior to release to operational units.

62. Shortcomings should be corrected.

63. The operator's manual should be changed to reflect all performance changes (paras 9, 2, 4, and 18).

64. Flight in instrument meterological conditions should be conducted only when tactically necessary (para 37).

65. The radio cabinets should be redesigned to allow easy access for maintenance (para 45).

66. The L-703 fuel control should be installed on all MULTEWS configured UH-1H helicopters (para 53).

67. The 212 ground handling wheel handle should be modified to provide safe clearance between the handle and the MULTEWS antenna boom (para 54).

68. The airspeed calibration data for MULTEWS should be included in the operator's manual (para 55).

69. The following NOTE should be included in the appropriate sections of the operator's manual (para 49).

NOTE

Operation of the engine anti-ice system will cause the MULTEWS ECU system to fault.

APPENDIX A. REFERENCES

1. Letter, AVSCOM, DRSAV-EQI, 7 June 1977, Test Request No. 77-09, Flight Evaluation of a UH-1H Helicopter Configured for Multiple Target Electronic Warfare System (MULTEWS).

2. Test Plan, USAAEFA Project No. 77-09, *Preliminary Airworthiness Evaluation, UH-1H Helicopter Equipped with Multiple Target Electronic Warfare System*, August 1977.

3. Test Plan Addendum, *Preliminary Airworthiness Evaluation, UH-1H Helicopter Equipped with Multiple Target Electronic Warfare System*, November 1977.

4. Letter, DRDAV-EQI, 12 August 1977, 25 August 1977 (R-1), 10 November 1977 (R-2), 17 November 1977 (R-3), 24 November 1977 (R-4), subject: Airworthiness Release for Preliminary Airworthiness Evaluation of an UH-1 Helicopter Configured for Multiple Target Electronic Warfare System (MULTEWS).

5. Technical Manual, TM 55-1520-210-10, *Operator's Manual, Army Model UH-1D/H Helicopter*, 25 August 1971.

6. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities; General Requirements For*, September 1961, with Amendment 1, 3 April 1962.

7. Final Report, US Army Aviation Systems Test Activity, Project No. 66-04, *Engineering Flight Test of the YUH-1H Helicopter, Phase D (Limited), Product Improvement Test*, November 1970.

8. Model Specification, No. 104.33, Lycoming Division of AVCO Corp., Model Specification T53-L-13/T53-L-13A/T53-L-13B (LTC1K-4/LTC1K-4E/LTC1K-4F) Shaft Turbine Engines, 30 September 1967, revised 30 September 1969.

9. Airworthiness Qualification Specification for MULTEWS UH-1H Helicopter Modification, Contract DAHCO7-7C-C-0210 CDRL AOOF TR-77-18, UTL Corporation, 19 May 1977.

10. Final Report, USAAEFA Project No. 75-01, *Performance and Handling Qualities, AH-1G Helicopter Equipped with Three Hot Metal/Plume Infrared Suppressors*, April 1975.

11. Army Regulation 310-25, Headquarters, Department of the Army, *Dictionary of United States Army Terms*, March 1969.

12. Boirun, B. H., "Generalizing Helicopter Flight Test Performance Data," Preprint No. 78-44, to be published in the Journal of the American Helicopter Society.

APPENDIX B. AIRCRAFT AND SYSTEM DESCRIPTION

GENERAL

The MULTEWS is mounted on a standard UH-1H airframe equipped with a Bell scoop IR suppressor kit. Descriptions of the aircraft, IR suppressor, and MULTEWS can be found on the following pages.

SOURCES OF INFORMATION

1. The information contained in this appendix was obtained from the operator's manual (ref 5, app A), the engine model specification (ref 8), Airworthiness Release (ref 4), and the detail specification for MULTEWS (ref 9). Information on the Bell scoop IR suppressor was obtained from USAAEFA Report No. 75-01 (ref 10).

2. The flight envelope and operating limitations were in accordance with TM 55-1520-210-10. The following additional cautions and limitations were observed:

a. Operation of the MULTEWS shall be conducted only with dummy loads installed on the RF amplifiers to preclude antenna radiation during evaluation flights.

b. In the event of in-flight emergencies, MULTEWS power will be immediately shut down.

c. A daily inspection of the RF antenna boom shall be made for security of attachment and evidence of any structural weakness.

d. Microwave energy radiation measurements shall be made inside the cabin area prior to first flight to ensure radiation levels are below 10 mw/cm^2. The system shall be shut down immediately if radiated energy exceeds 10 mw/cm^2.

e. The electrical load of the 30-KVA alternator shall be monitored prior to the first flight during which MULTEWS is fully operational. Operation of MULTEWS shall be discontinued if the load exceeds 15 KVA.

f. The cargo door plexiglass panels have been replaced with sheet metal. Crash rescue support personnel shall, therefore, be briefed on emergency entrance to the cabin area should the cargo doors become jammed.

g. Flight load data shall be monitored in real time during flight. If any of the following limits are exceeded, flight shall be terminated.

(1) The strain gage located on the forward left-hand vertical fin spar should measure no more than a sustained oscillatory stress of 3000 psi and a transient oscillatory stress of 7500 psi. Readings of sustained oscillatory stress above 3000 psi will be acceptable providing the following conditions are met:

(a) Readings greater than 3000 psi shall be divided into three (3) groups (3000 - 4500 psi, 4500 - 6000 psi, 6000 - 7200 psi) and cycle counted.

(b) Using the high reading of each group as base, compute using Miner's Rule (n/N).

(c) Summation of n/N shall not exceed 0.5 before the subject part is replaced.

(d) If readings greater than 7200 psi are encountered, flight shall be terminated.

(e) The following table shall be used to define the value of N:

Stress (psi)	N (cycles)
3000 - 4500	1×10^5
4500 - 6000	2×10^4
6000 - 7200	1×10^4

(2) The strain gage located on the upper left hand longeron, just aft of the tail boom splice fitting, should measure no more than a sustained oscillatory stress of 3000 psi and a transient oscillatory stress of 7500 psi.

(3) The resulting moment from the beamwise and chordwise bending bridges located just outboard of the inboard stabilizer closure rib should not exceed a sustained oscillatory moment of 3000 inch-pounds and a transient oscillatory moment of 4400 inch-pounds. Readings of sustained oscillatory moments above 3000 inch-pounds will be acceptable providing the conditions of paragraph 2g(1)(a) through 2g(1)(e) above are met, substituting inch-pounds for psi.

(4) The axial load indicator, on the horizontal stabilizer control tube that connects to the stabilizer pitch horn, should not have a sustained load greater than 234 pounds and a transient load greater than 700 pounds.

h. The MULTEWS antennas shall be removed and replaced with dummy antennas during the height-velocity tests. Easily removable internal electronic gear shall be removed and stored.

DESIGN DATA

3. The pertinent design data for the UH-1H is listed as follows:

Overall Dimensions

Length (rotor turning)	57 ft, 1.1 in.
Length (nose to tail)	41 ft, 11.1 in.
Width of skids (maximum width except rotor)	9 ft, 6.6 in.
Height (to top of rotor mast)	14 ft, 0.7 in.
Fuselage ground clearance (at design weight)	1 ft, 3.0 in.
Main rotor clearance (rotor tip to tail boom static)	1 ft, 10.7 in.

Weights

Manufacturer's empty weight	4973 lb
User's empty weight	5400 lb
Design gross weight	6600 lb
Maximum overload gross weight	9500 lb

Main Rotor

Number of blades	2
Rotor diameter (blades)	48 ft
Rotor diameter (including tracking tips)	48 ft, 3.2 in.
Blade chord (root to tip)	21 in.
Blade airfoil (root to tip)	NACA 0012
Blade twist (root to tip)	-10 deg
Preconing angle	2.75 deg
Mast angle	5 deg forward tilt
(Relative to horizontal reference)	
Control travel:	
(measured at center of grip)	
Collective	11.2 in. (27 deg)
Longitudinal cyclic	12.3 in. (30 deg)
Lateral cyclic	12.6 in. (30 deg)
Directional	6.7 in.
Blade travel:	
Flapping (any direction)	±11 deg
Collective (measured at 75% radius)	0 to 15 deg
Longitudinal cyclic	±12 deg
Lateral cyclic	±10 deg

Tail Rotor

Number of blades	2
Rotor diameter	8 ft. 6 in.
Blade chord (root to tip)	8.41 in.
Blade airfoil (root to tip)	NACA 0015
Pedal travel	6.7 in.
Blade travel:	
Thrust to right (left yaw)	±19 deg
Thrust to left (right yaw)	-7 deg

DERIVED DATA

Main Rotor

Disc area (total swept area)	1810 ft^2
Blade area (including hub)	82 ft^2
Solidity	0.0464
Disc loading:	
6600 lb	3.65 lb/ft^2
9500 lb	5.25 lb/ft^2

Blade loading:	
6600 lb	80.5 lb/ft^2
9500 lb	115.9 lb/ft^2
Power loading:	
(1137 shp)	
6600 lb	5.80 lb/shp
9500 lb	8.36 lb/shp
Tip speed in a hover:	
324 rpm (maximum)	814.3 fps (482.5 kt)
294 rpm (minimum)	738.9 fps (437.8 kt)
Maximum tip speed in forward flight:	
(V_T - 123.6 kt)	
Power on (324 rpm)	1022.9 fps (605.7 kt)
Power off (339 rpm)	1060.6 fps (628.4 kt)

Tail Rotor

Disc area (total swept area)	56.7 ft^2
Blade area (including hub)	5.96 ft^2
Solidity	0.105
Tip speed in a hover:	
324 rpm	736 fps (436 kt)
294 rpm	668 fps (395 kt)
Tail rotor speed (324 rpm main rotor speed)	1654.1 rpm

Gear Ratios

Power turbine to output shaft	3.2105:1
Output shaft to main rotor	20.370:1
Output shaft to tail rotor	3.990:1
Gas producer turbine to tach pad (100% = 25,150 rpm)	5.988:1

FLIGHT LIMITATIONS

Power ratings:	
Military power (30-minute limit)	1400 shp
Maximum continuous power	1250 shp
Transmission rating	1137 shp
Torque limits:	
Maximum continuous	50 psi
Transient overtorque (not to be used intentionally) (no maintenance required)	50 to 54 psi
Transient overtorque (inspect drive train)	54 to 61 psi
Transient overtorque (replace all drive train and rotor components)	Over 61 psi

Output shaft speed:	
Maximum steady state	6600 rpm
Minimum steady state	6400 rpm
Minimum steady state below 7500 lb	6000 rpm
Maximum transient (below 91% N_1) (not to be used intentionally)	6750 rpm

Exhaust Gas Temperature

Maximum continuous	390° to 625°C
30-minute limit	625° to 645°C
5-second limit for starting and acceleration	675°C
Maximum for starting and acceleration	760°C

Gas Producer

Maximum speed	25,600 rpm (101.8%)
Flight idle speed	15,900 to 17,000 rpm (63 to 68%)
Ground idle/start speed	12,100 to 13,100 rpm (48 to 52%)

Rotor Speed

Maximum power on	324 rpm
Power on transient	331 rpm
Power off	339 rpm
Mimimum power on	314 rpm
Power on less than 7500 lb	294 rpm
Power off	294 rpm

Airframe

Loading:	
Design weight	6600 lb
Maximum overload weight	9500 lb
Maximum floor loading	300 lb/ft^2
Maximum cargo hook capacity	4000 lb
Maximum forward cg	Sta 130
Maximum aft cg	Sta 144
Maximum lateral cg	±7.5 in.

Limit load factors:	
Positive 6600 lb	±3.0g
9500 lb	±2.1g
Negative 6600 lb	-0.5g
9500 lb	-0.35g

Airspeed:

Forward flight	
Maximum	123.6 KTAS at 2000 ft
Sideward and rearward flight	
Maximum	30 KTAS

BELL SCOOP INFRARED SUPPRESSOR

4. The Bell scoop IR suppressor system (MWO 55-1520-210-30-44), manufactured by Bell Helicopter Textron, is a suppressor system that was fielded during the Vietnam conflict to counter IR-seeking missiles. This device was designed to reduce IR radiation produced by hot engine, oil cooler, and exhaust system components, and to provide protection against attack from the ground only. The kit consists of an insulated upturned elbow, two plates for either side of the engine cowling inlet area, and a single plate to cover the oil cooler exhaust and attaching hardware. The ejector nozzle and insulated elbow provide enough airflow to cool the engine compartment only, and not enough air to dilute the exhaust plume.

MULTIPLE TARGET ELECTRONIC WARFARE SYSTEM DESCRIPTION

5. The MULTEWS configuration consists of the AN/ALQ-143 system and support ancillary items which are installed in the UH-1H helicopter. The AN/ALQ-143 system consists of the command and control subsystem (photo 1), receiver subsystem, control and display subsystem, jammer subsystem, support ancillary items for the doppler navigation systen, AN/ASN-128 (Ryan), aircraft power distribution system (30 KW), and voice communication system (AN/ARC-114).

6. The overall configuration requires minor airframe modification and installation of two externally mounted antenna assemblies (photos 2 through 4). Environmentally cooled (using bleed air) mission equipment cabinets are installed within the cabin compartment (photo 5). The mission equipment operator is provided with an adjustable forward facing seat and console which contains the mission equipment controls, displays, and communications. The mission equipment primary and secondary power source requires replacement of the transmission-driven DC generator with a 30-KW AC unit and adds a 5-KVA inverter to the system. The AN/ASN-128 doppler naviation system is installed to provide aircraft position and attitude input data to the mission equipment. Radio frequency (RF) shielding is provided the on-board flight crew by screening windows in line with microwave energy radiated from the externally installed antennas. The windows in each of the cargo doors were replaced with sheet metal. Each cargo door and pilot and copilot doors were interlocked into the MULTEWS system. The windows in the pilot and copilot doors were covered with protective screens. Figures 1 and 2 show the MULTEWS helicopter equipment configuration.

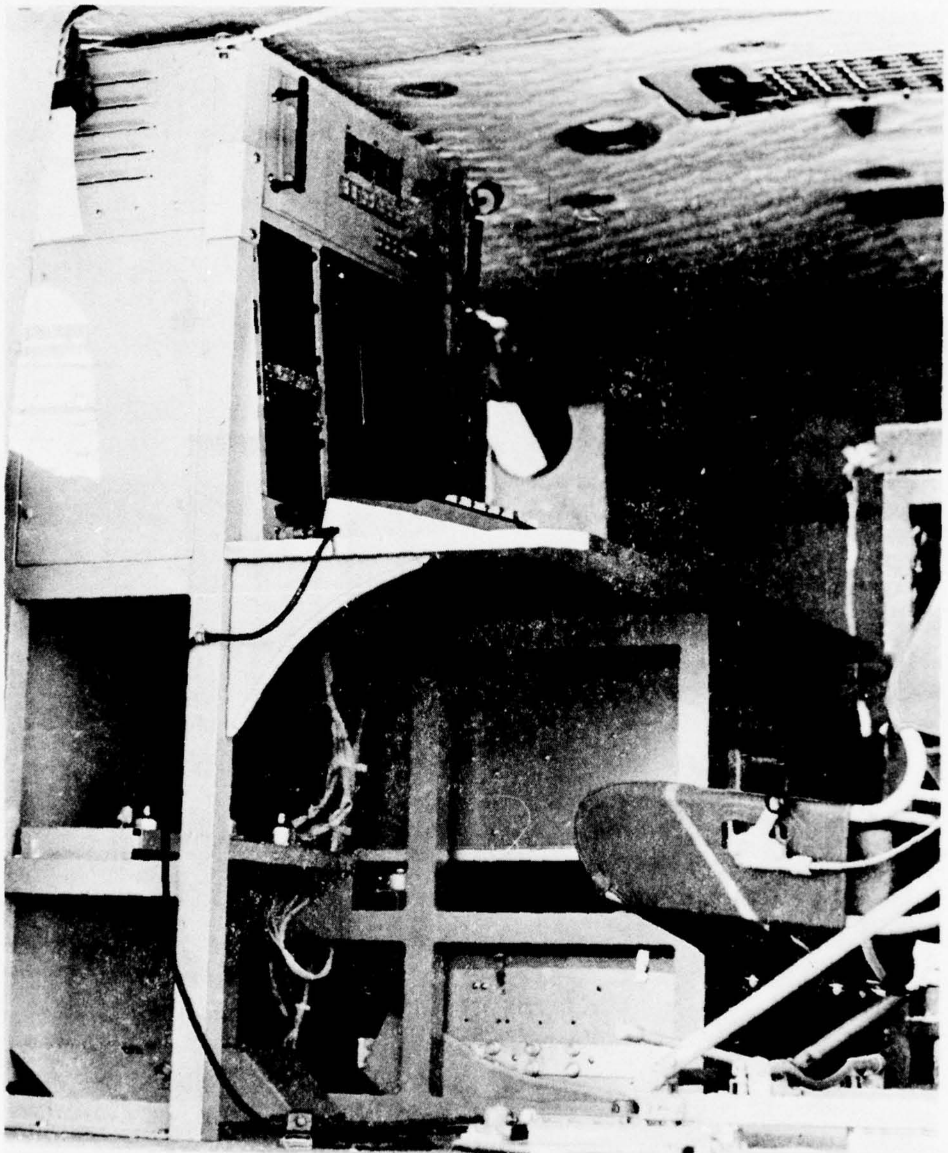


Photo 1. AN/ALQ 143 Control and Display Subsystem.

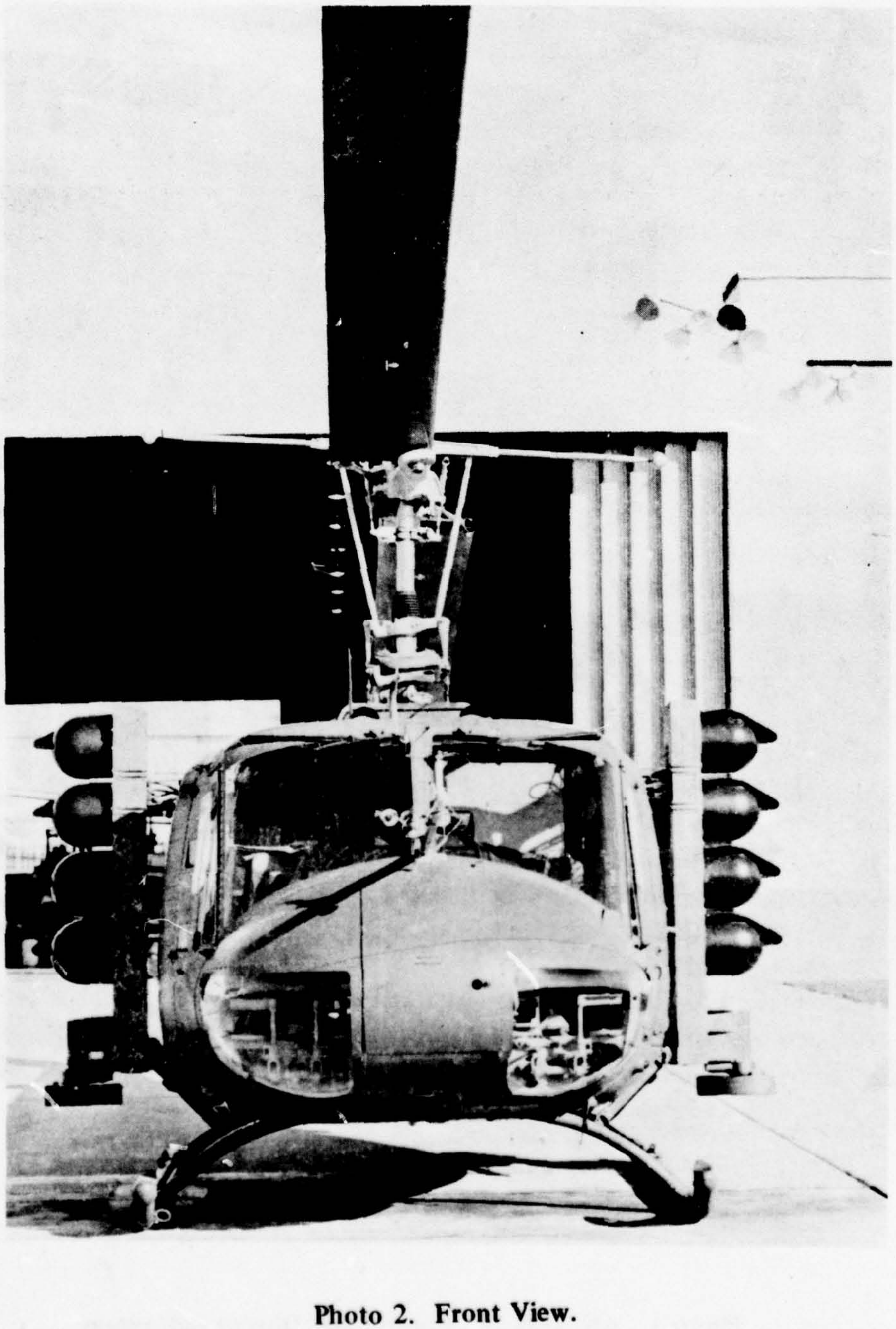


Photo 2. Front View.

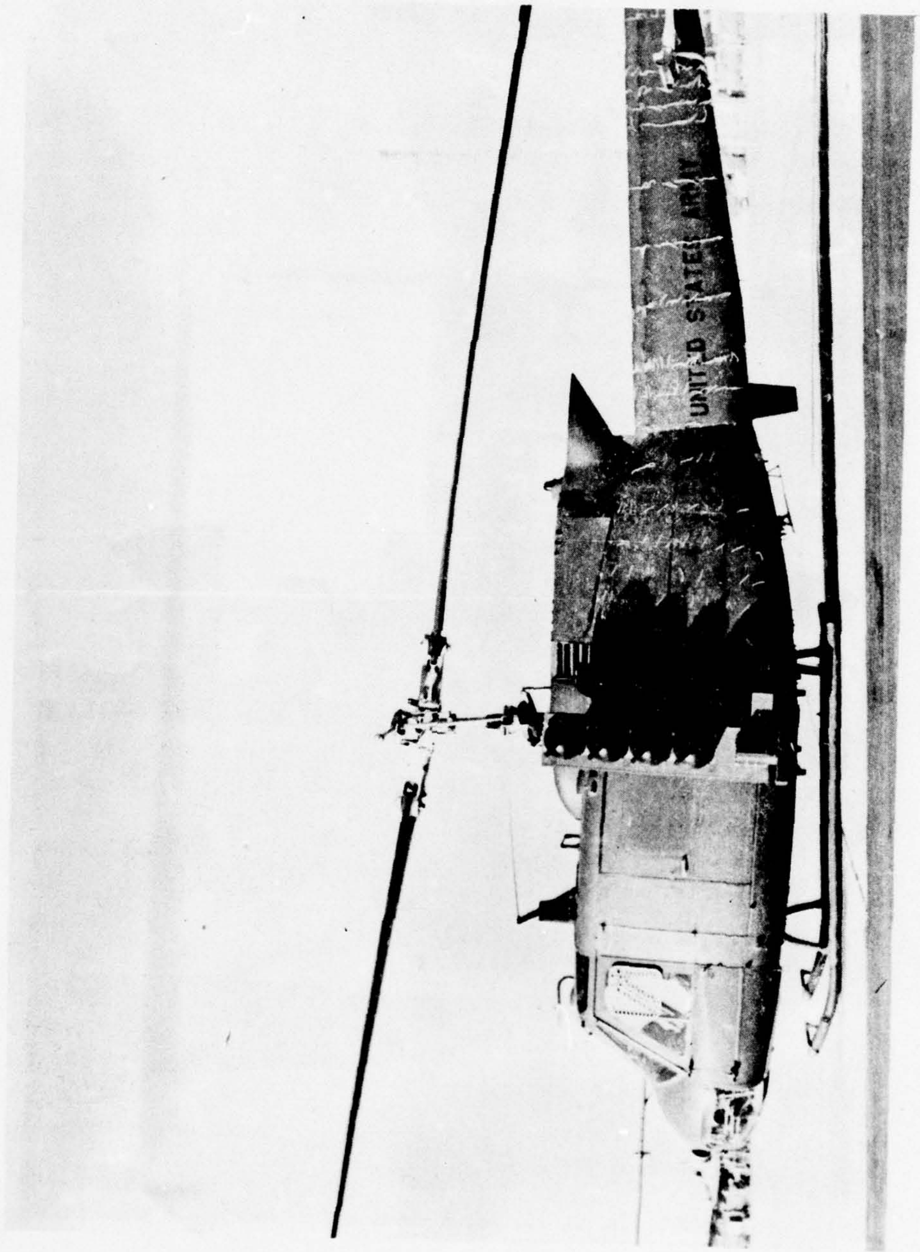


Photo 3. Left Side View.

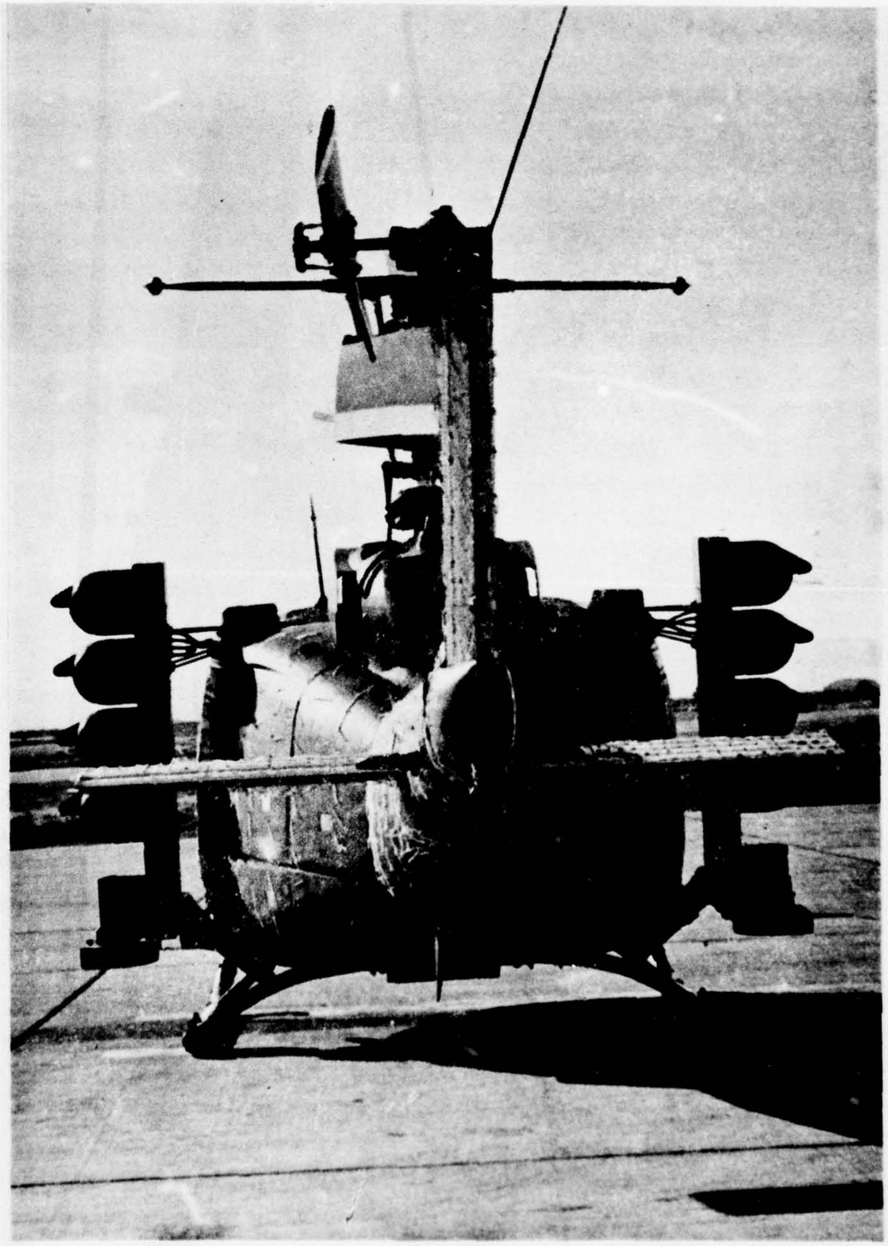


Photo 4. Aft View.

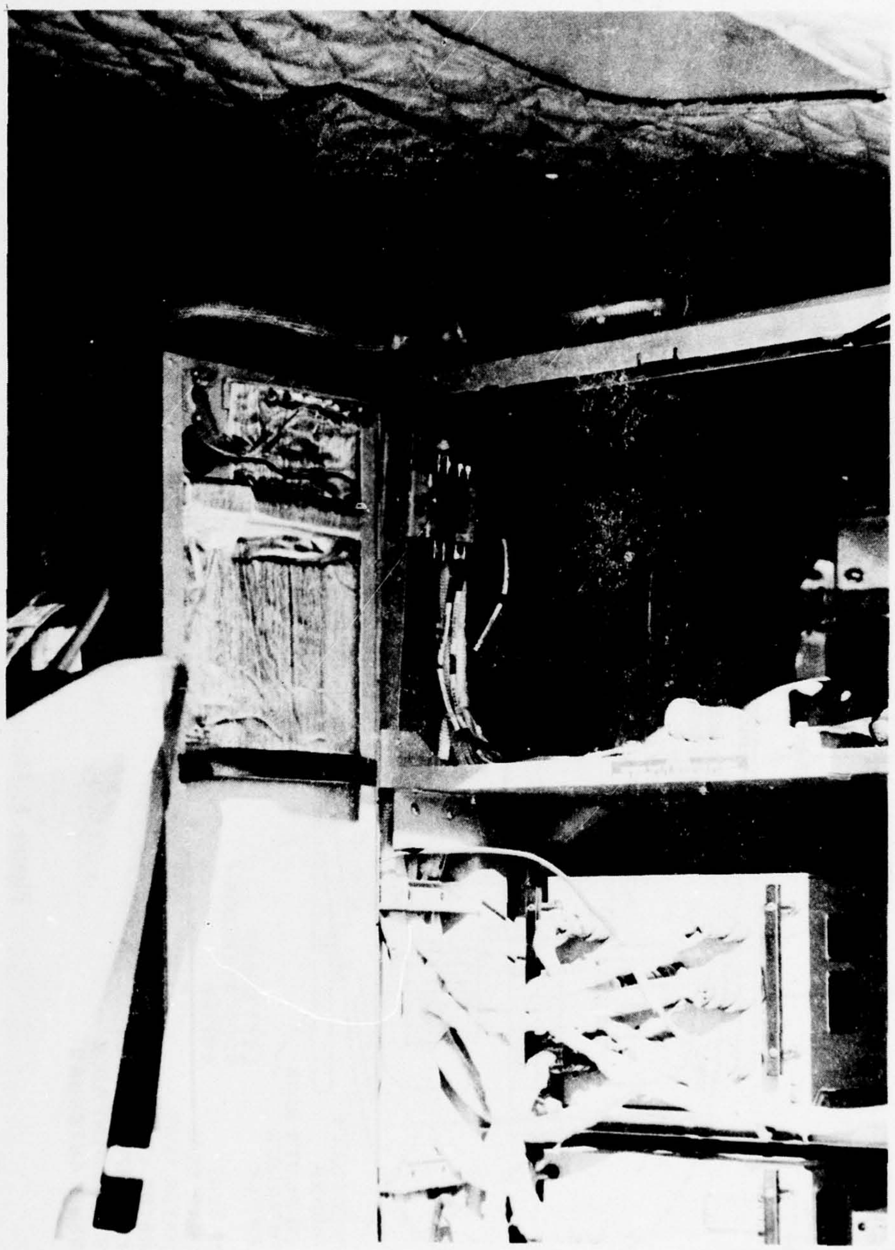


Photo 5. Mission Equipment Cabinets.

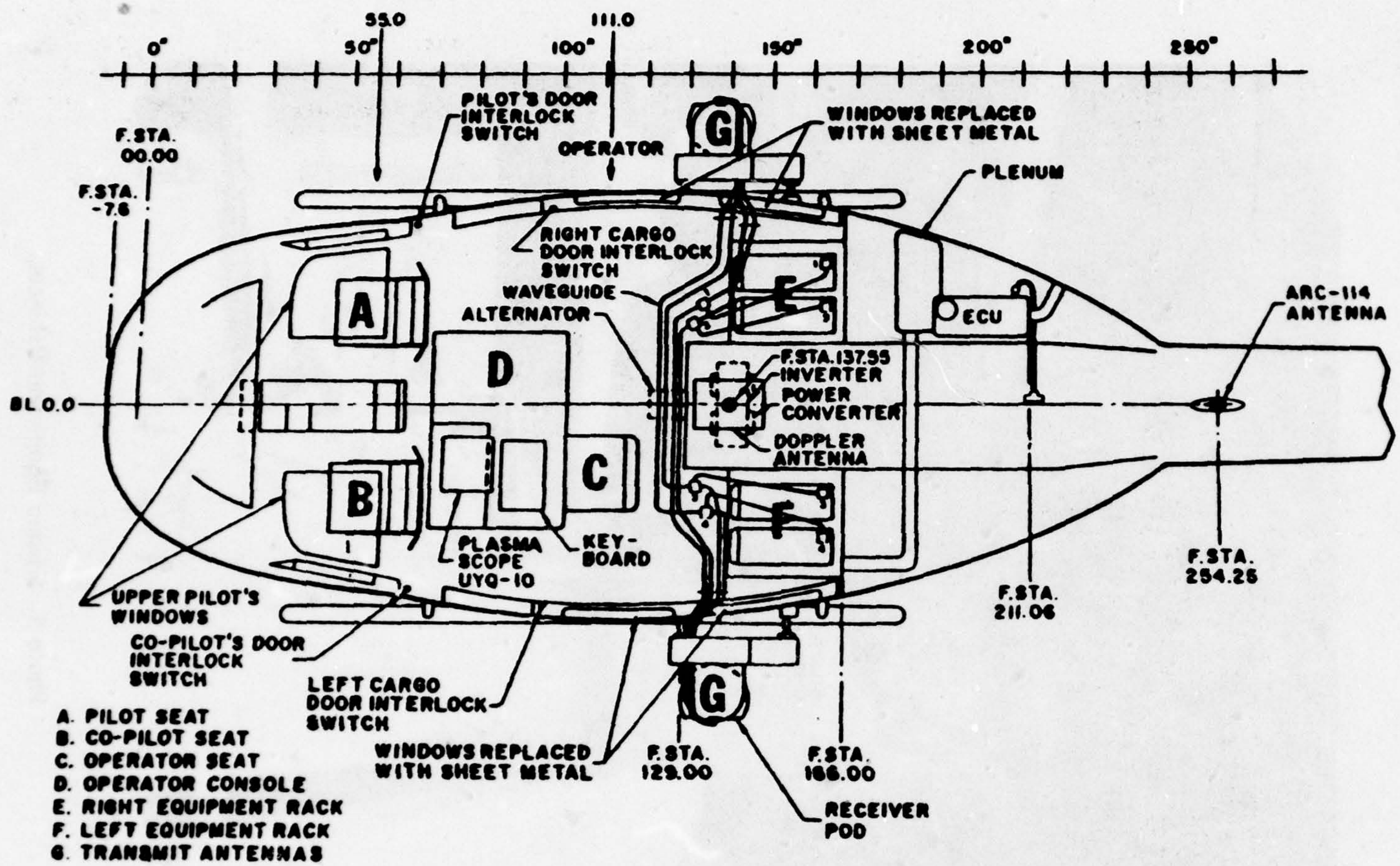


Figure 1. Multews Installation Plan View.

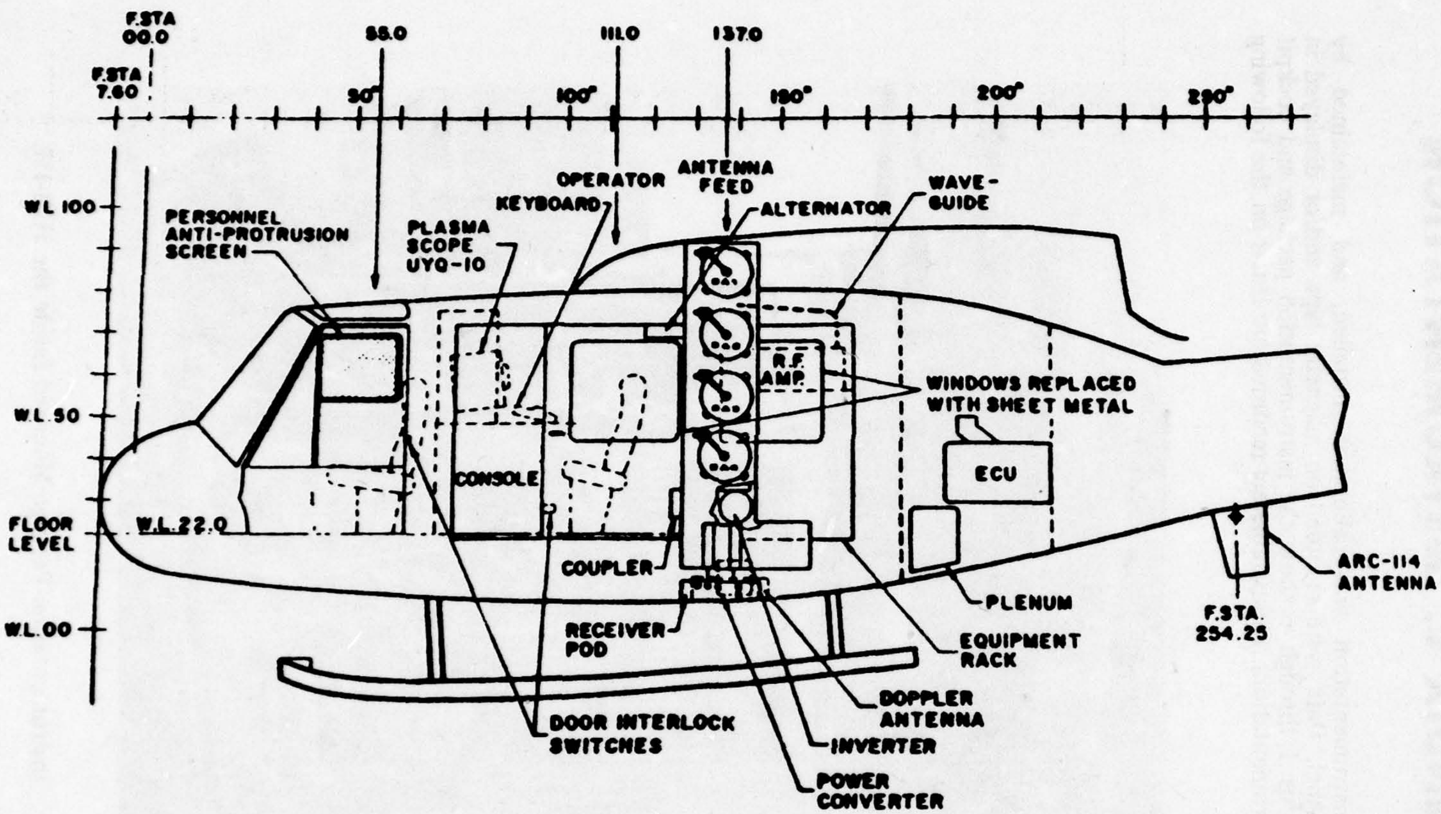


Figure 2. Multews Installation Elevation View.

APPENDIX C. INSTRUMENTATION

1. The test instrumentation was calibrated, installed, and maintained by USAAEFA personnel. Data were recorded on magnetic tape and/or displayed in the cockpit. Photos 1 through 6 show the instrumentation package and cockpit and external instrumentation. The **parameters** recorded are listed on the following pages.

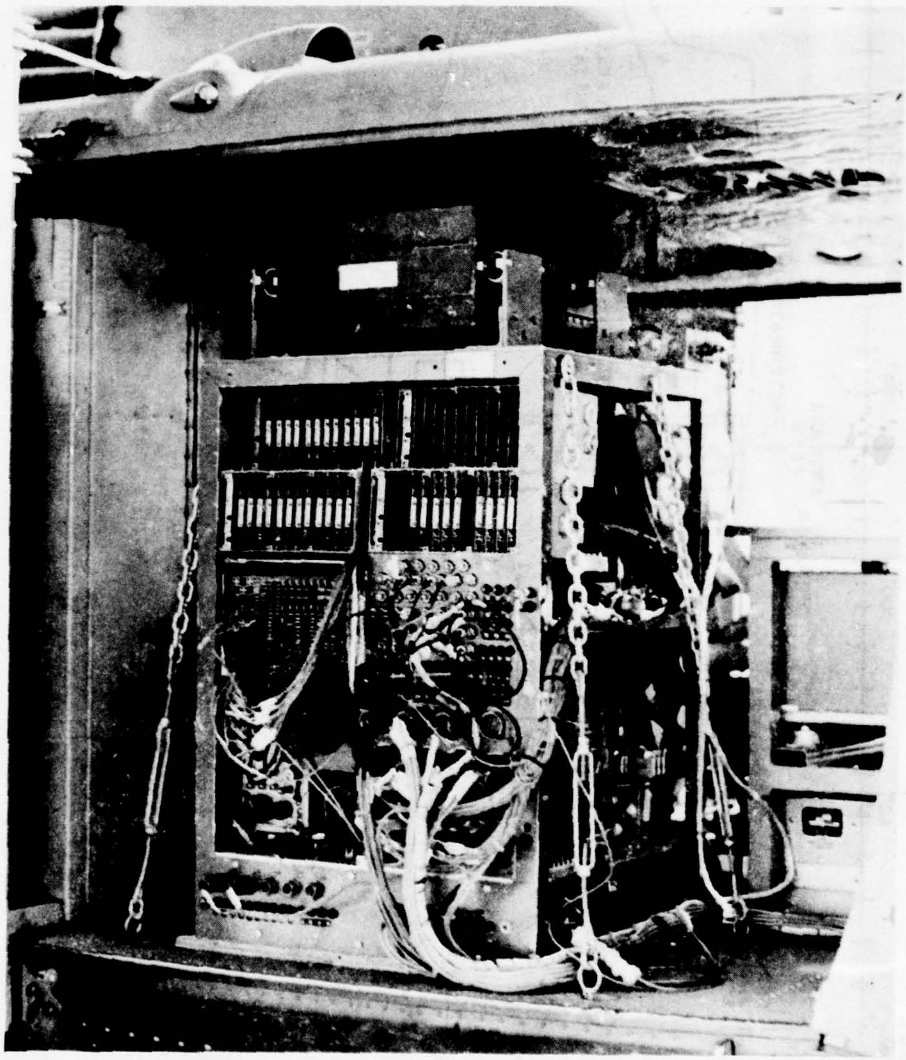


Photo 1. Instrumentation Package Mounted Inside the JUH-1H.

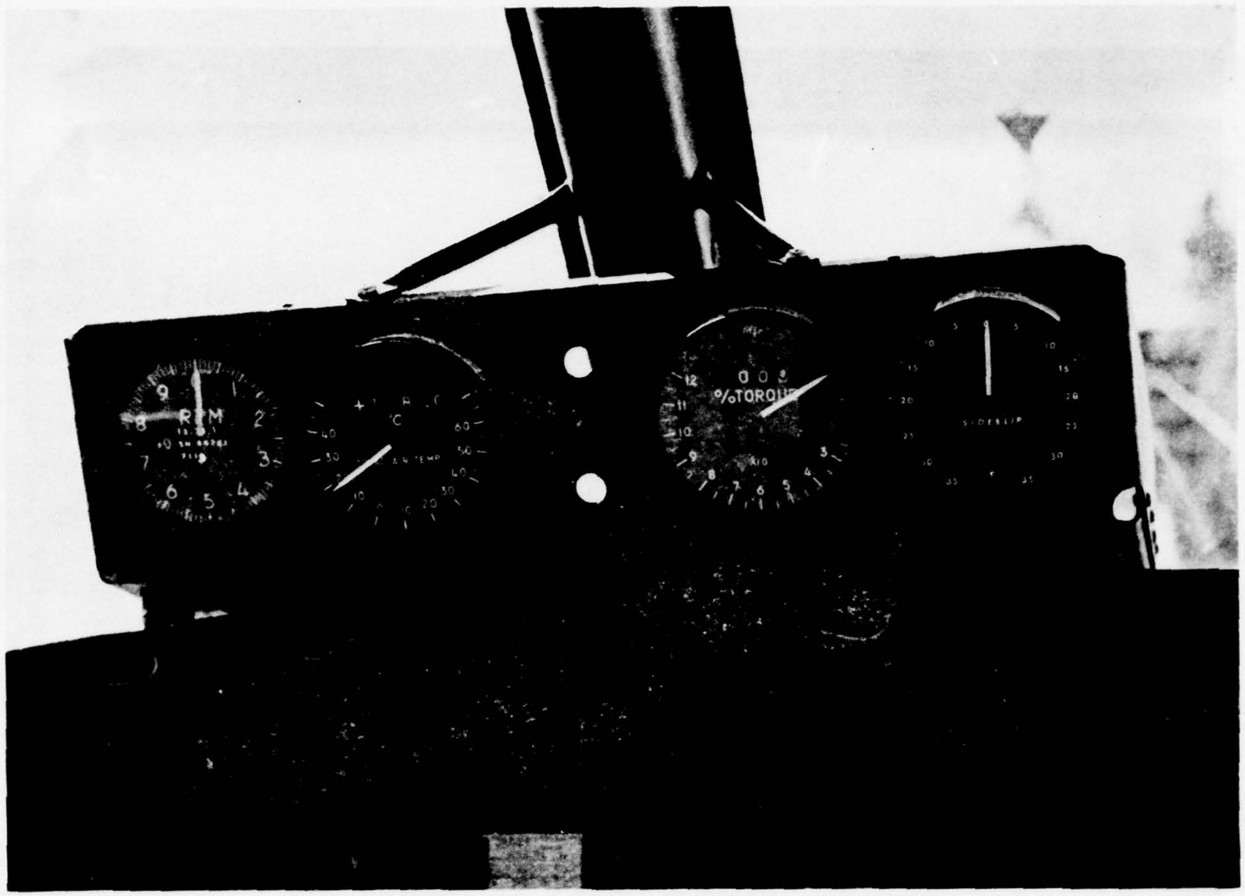


Photo 2. Sensitive Instrumentation Mounted on the Cockpit Glare.

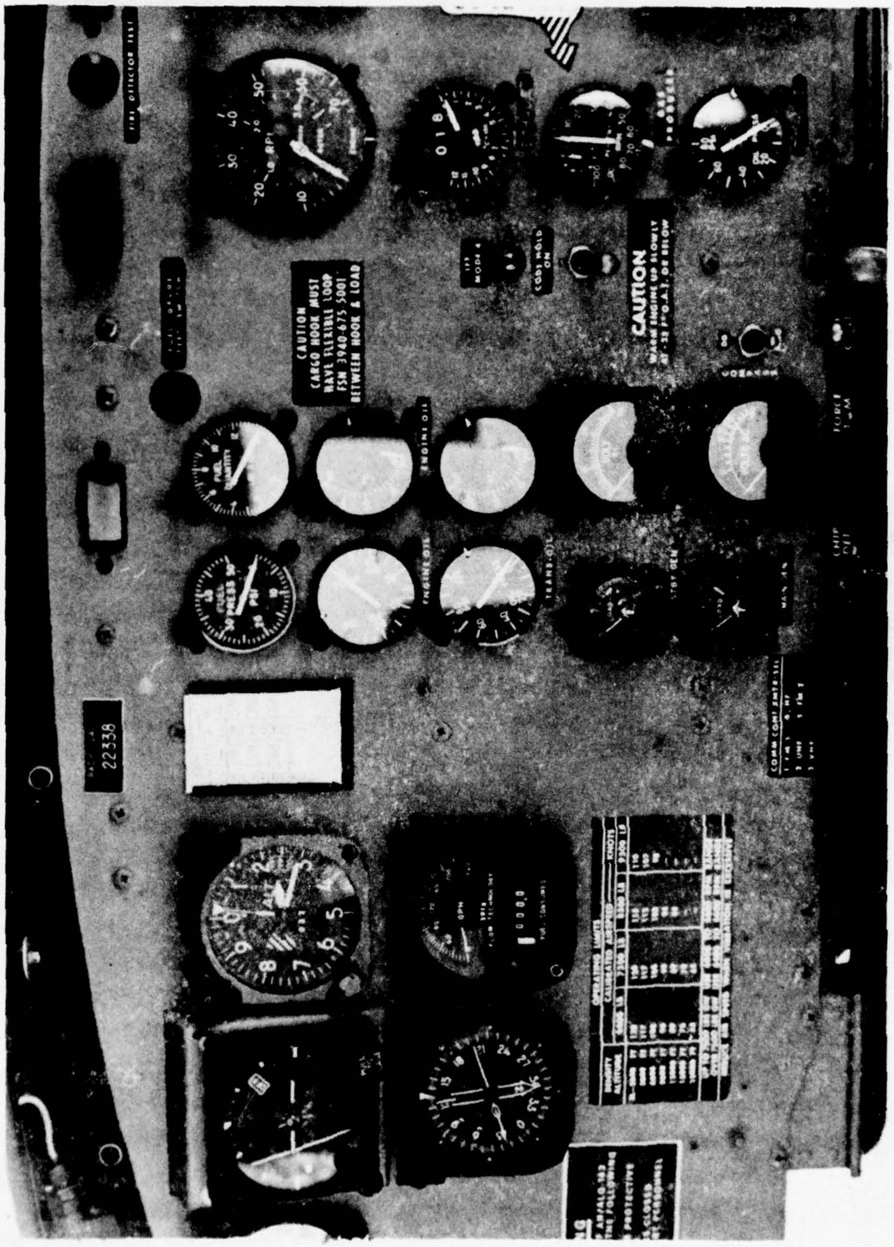


Photo 3. Cockpit Instrumentation.

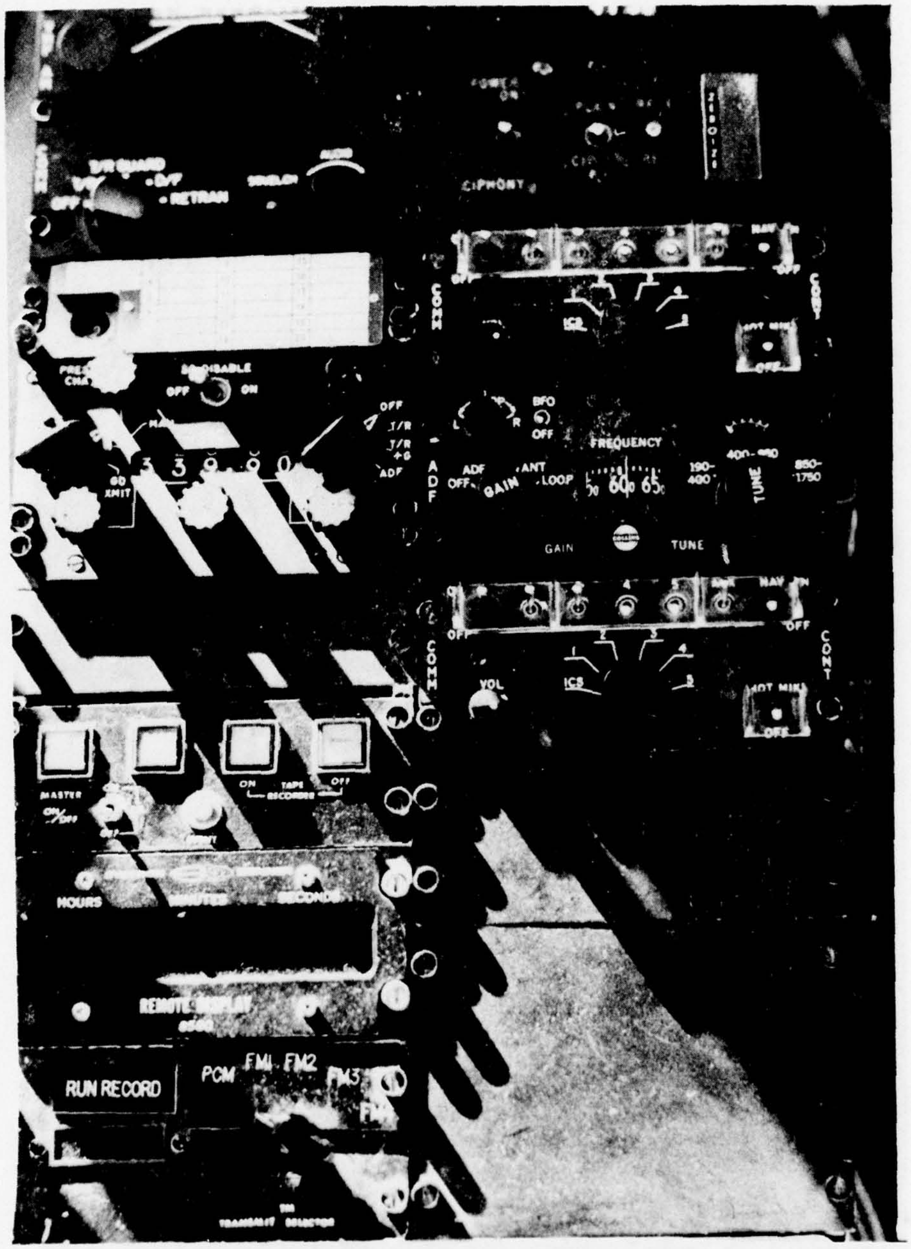


Photo 4. Magnetic Tape Remote Display Module.

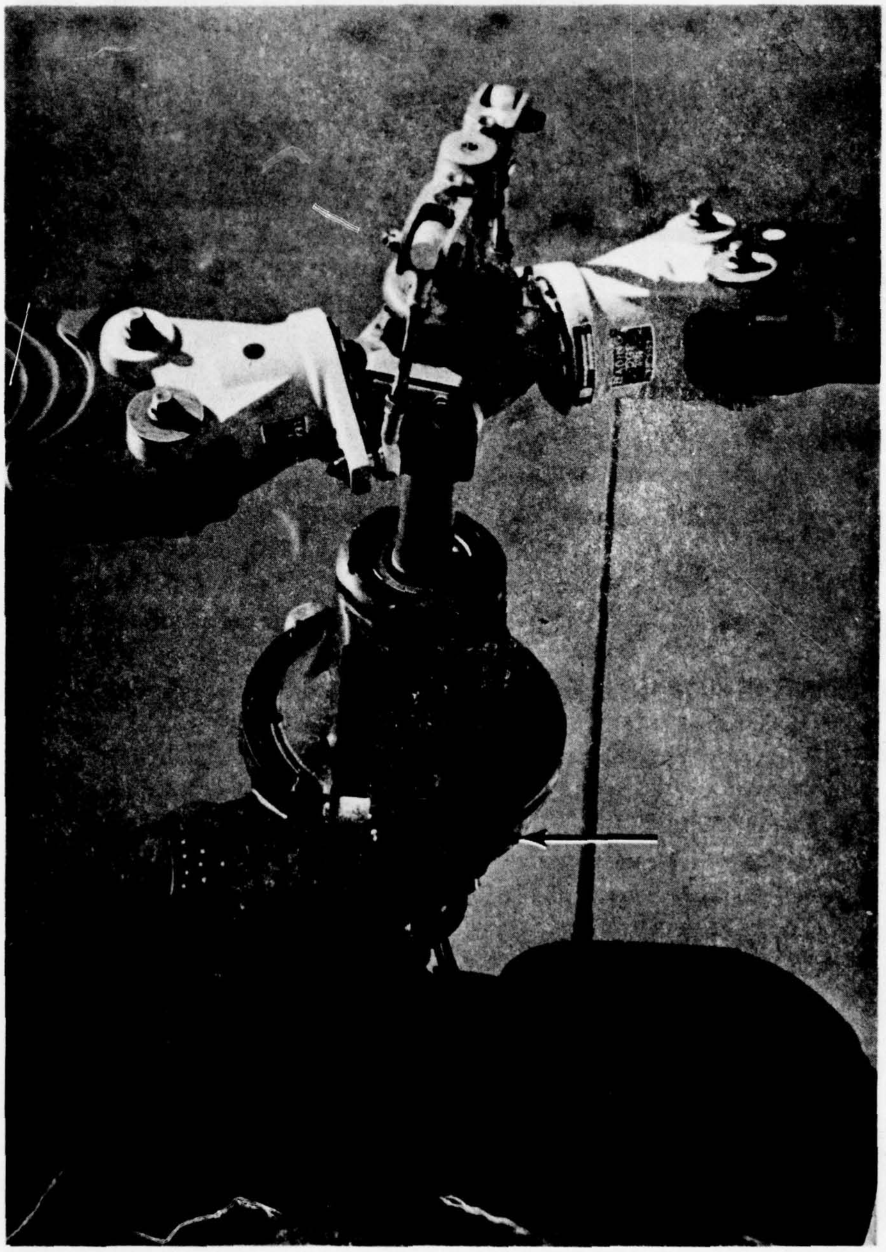


Photo 5. Tail Boom Accelerometers Mounted on the 90° Gear Box.

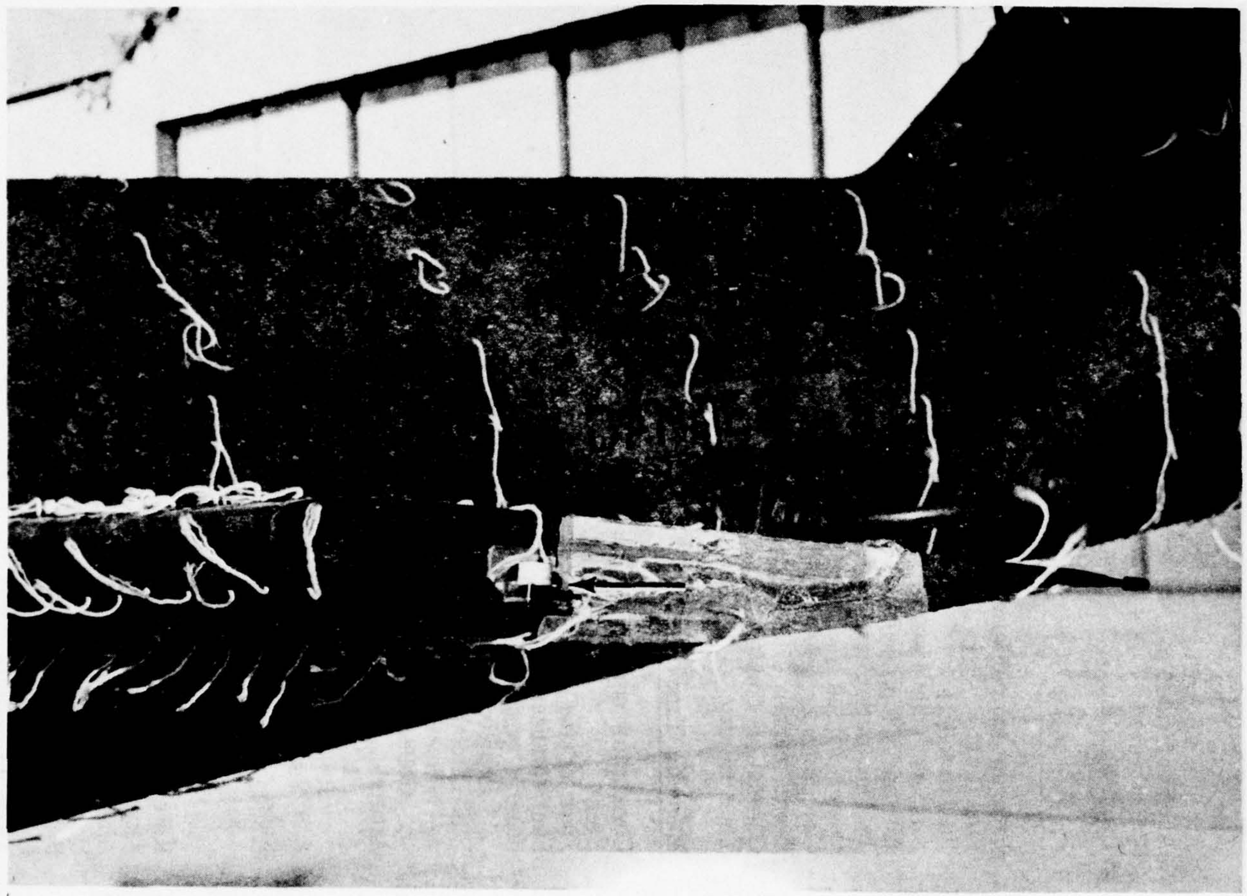


Photo 6. Horizontal Stabilizer Vertical Strain Gage.

Pilot Panel

Airspeed (boom)
Altitude (boom)
Angle of sideslip
Rotor speed
Event marker

Copilot Panel

Free air temperature
Fuel flow
Fuel totalizer
Airspeed (ship's system)
Altitude (ship's system)
Turbine outlet temperature
Engine torque
Gas producer speed
Event marker
Correlation counter
Time of day

Magnetic Tape

Correlation counter
Event
Time of day
Fuel totalizer
Control position:
- Longitudinal
- Lateral
- Directional
- Collective

Attitude:
- Pitch
- Roll
- Yaw

Rate:
- Pitch
- Roll
- Yaw

Rotor speed
Altitude (boom)
Airspeed (boom)
Engine torque
Free air temperature
Gas producer speed
Angle of sideslip

Turbine outlet temperature
Center-of-gravity normal acceleration
Ground speed (ASN-128)
Accelerometer location:
Pilot station (triaxial piezoelectric)
Center of gravity (triaxial piezoelectric)

2. During the second phase of testing, the flight test boom was removed, which removed boom airspeed, boom altitude, and sideslip instrumentation. Accelerometers and strain gages were added as shown below, and telemetry was installed to monitor in-flight loads. A radar altimeter with cockpit display was added for the H-V testing.

Accelerometer location (Strain gauge accelerometers)	Fuselage Station	Butt Line	Waterline
Pilot station (triaxial)	60.0	25.0 right	22.0
Center of gravity (triaxial)	120.0	13.0 right	22.0
Tail rotor gear box (triaxial)	479.0	1.0 left	130.0
Horizontal stabilizer vertical	363.5	56.0 left	70.0

Strain Gage Location (N)	Fuselage Station	Butt Line	Waterline
Horizontal stabilizer vertical	363.5	12.5 left	70.0
Horizontal stabilizer longitudinal	363.5	12.5 left	70.0
Horizontal stabilizer control	363.0	6.0 right	60.0
Tail boom	247.0	13.0 left	61.0
Tail boom flange	430.0	4.0 left	84.0

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

GENERAL

1. Estabished test techniques and data analysis methods were used in both the performance and handling qualities tests. Descriptions of the test techniques are contained in this appendix. The Handling Qualities Rating Scale presented in figure 1 was used to augment pilot comments relative to handling qualities. A Vibration Rating Scale (fig. 2) was used to augment pilot comments relative to vibrations. Definitions of deficiencies and shortcomings are as stipulated in Army Regulation 310-25 (ref 11, app A). Climb, level flight, autorotational descent performance, and static lateral-directional stability tests were conducted at zero sideslip. All other tests were conducted in coordinated flight (ball centered).

DATA ANALYSIS

Nondimensional Coefficients

2. The helicopter performance test data were generalized by use of nondimensional coefficients. The following nondimensional coefficients were used to generalize the hover, climb, level flight, and autorotational results obtained during this evaluation:

a. Coefficient of power (C_P):

$$C_P = \frac{SHP \times 550}{\rho A (\Omega R)^3} \qquad (1)$$

b. Coefficient of thrust (C_T):

$$C_T = \frac{GW}{\rho A (\Omega R)^2} \qquad (2)$$

c. Advance ratio (μ):

$$\mu = \frac{1.6878\ V_T}{\Omega R} \qquad (3)$$

d. Advancing blade tip mach number (M_{TIP}):

$$M_{tip} = \frac{1.6878\ V_T + (\Omega)}{a} \qquad (4)$$

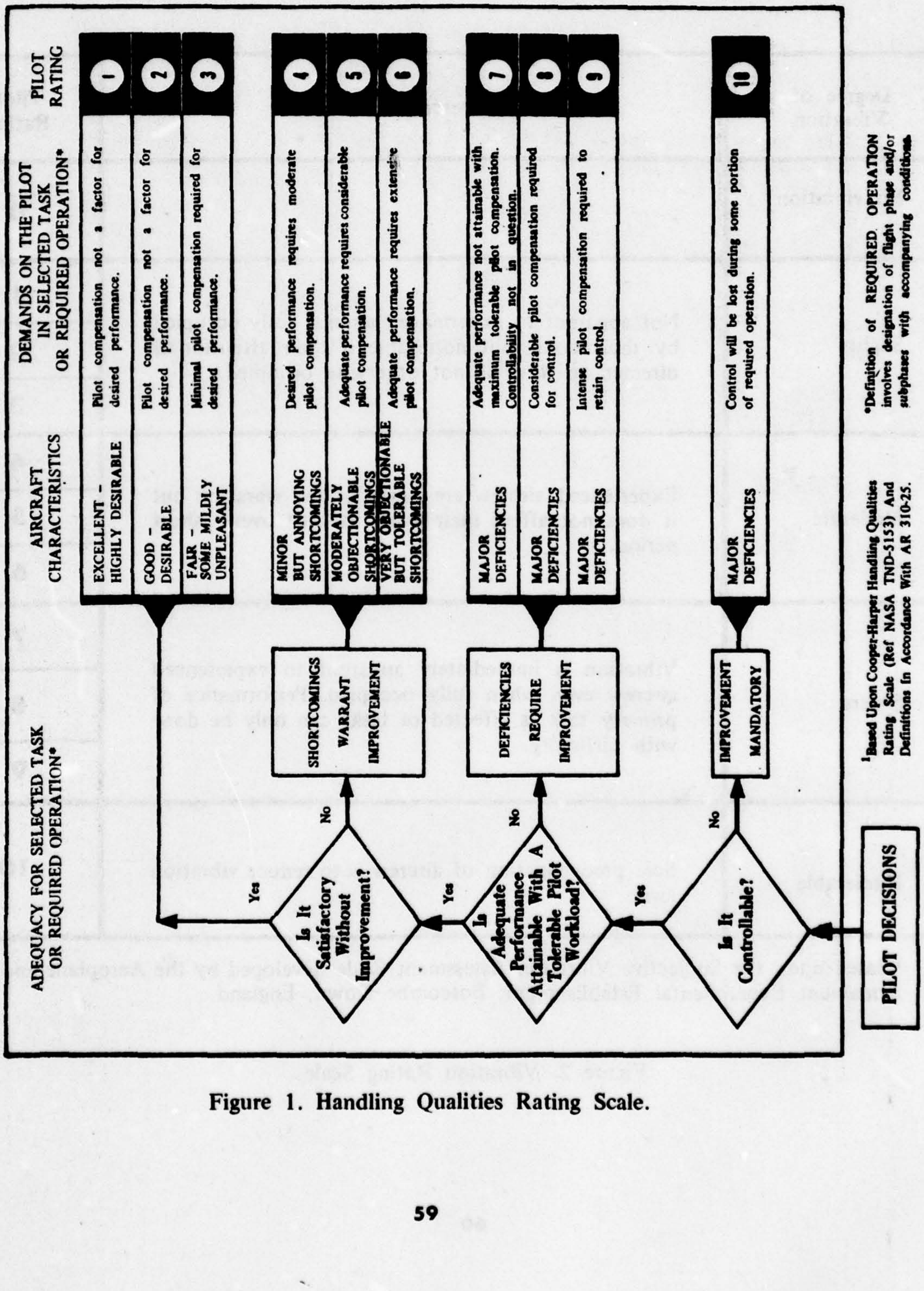


Figure 1. Handling Qualities Rating Scale.

Degree of Vibration	Description[1]	Pilot Rating
No vibration		0
Slight	Not apparent to experienced aircrew fully occupied by their tasks, but noticeable if their attention is directed to it or if not otherwise occupied.	1
		2
		3
Moderate	Experienced aircrew are aware of the vibration but it does not affect their work, at least over a short period.	4
		5
		6
Severe	Vibration is immediately apparent to experienced aircrew even when fully occupied. Performance of primary task is affected or tasks can only be done with difficulty.	7
		8
		9
Intolerable	Sole preoccupation of aircrew is to reduce vibration level.	10

[1] Based upon the Subjective Vibration Assessment Scale developed by the Aeroplane and Armament Experimental Establishment, Boscombe Down, England.

Figure 2. Vibration Rating Scale.

Where:

SHP = Engine output shaft horsepower

550 = Conversion factor (ft-lb/sec/shp)

ρ = Air density (slug/ft^3)

A = Main rotor disc area (ft^2)

Ω = Main rotor angular velocity (radian/sec)

R = Main rotor radius (ft)

GW = Aircraft gross weight (lb)

V_T = True airspeed (kt)

a = Speed of sound (ft/sec)

1.6878 = Conversion factor (ft/sec/kt)

True airspeed (V_T) was calculated using calibrated airspeed (V_{CAL}) and density ratio (σ) as follows:

$$V_T = \frac{V_{CAL}}{\sqrt{\sigma}} \qquad (5)$$

Where:

$\sigma = \rho/.0023769$

Shaft Horsepower Required

3. The engine output shaft torque was determined from the engine manufacturer's differential torque pressure system. The relationship of measured differential torque pressure (psi) to engine output shaft torque (ft-lb) is illustrated in figure 3. The output shp was determined from the engine output shaft torque and rotational speed by the following equation.

$$SHP = \frac{2\pi \times N_P \times Q}{33000} \qquad (6)$$

Where:

N_P = Engine outputs shaft rotational speed (rpm)

Q = Engine output shaft torque (ft-lb)

33,000 = Conversion factor (ft-lb/min/shp)

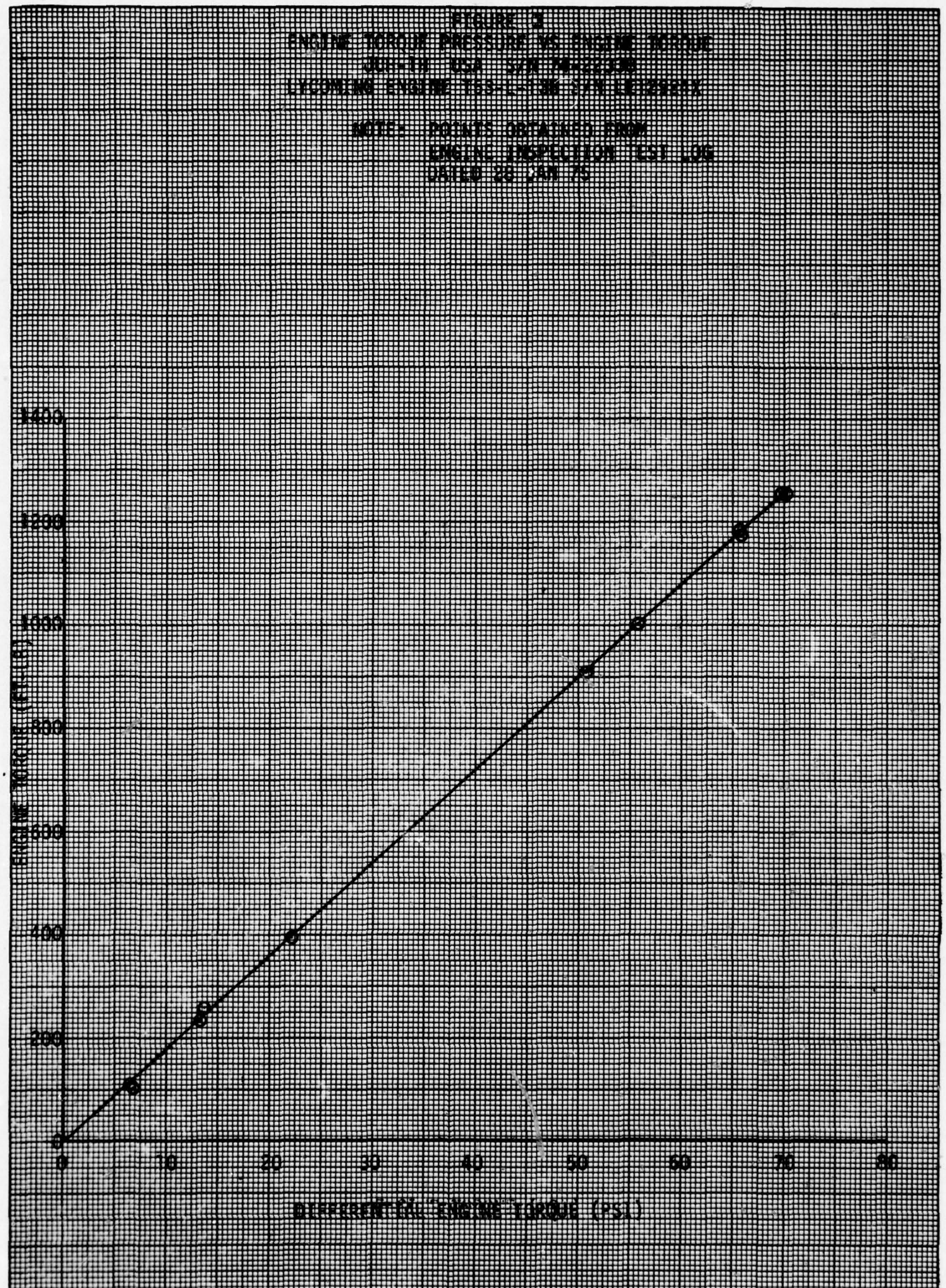


FIGURE 3
ENGINE TORQUE PRESSURE VS ENGINE TORQUE
NOTE: POINTS OBTAINED FROM
ENGINE INSPECTION TEST LOG
DATED 28 JAN 75
ENGINE TORQUE (FT LB)
1400
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
DIFFERENTIAL ENGINE TORQUE (PSI)

Level Flight Performance and Specific Range

4. Level flight speed power performance was determined by using equations 1, 2, and 3. Each speed power was flown using zero sideslip at a predetermined constant C_T by maintaining a constant referred gross weight (W/δ) and referred rotor speed ($N/\sqrt{\theta}$). A constant W/δ was maintained by increasing altitude (decreasing δ) as fuel was consumed. Rotor speed was also varied to maintain a constant ratio of $N/\sqrt{\theta}$ as the ambient air temperature varied.

5. Test-day level flight power was corrected to standard-day conditions using equations 7 and 8.

$$VT_s = VT_t \left(\frac{\Omega R_s}{\Omega R_t}\right) \tag{7}$$

$$SHP_s = \frac{P_s}{P_t} \left(\frac{\Omega R_s}{\Omega R_t}\right)^3 SHP_t \tag{8}$$

Where:

t = Test day

s = Standard day

6. Specific range was calculated using level flight performance curves and the specification installed engine fuel flow characteristics.

$$NAMPP = \frac{V_T}{W_f} \tag{9}$$

Where:

NAMPP = Nautical air miles per pound of fuel

V_T = True airspeed (kt)

W_F = Fuel flow (lb/hr)

7. The equivalent flat plate area (fe) for a standard UH-1H (propulsive efficiency factor assumed unity) was calculated by the following equation using incompressible data from reference 12, appendix A.

$$fe = \frac{2}{3}\frac{A}{\mu^2}\frac{dC_P}{d\mu} - 0.8\mu C_T^{1.29} + \frac{.365}{\mu^2} C_T^{1.79} \tag{10}$$

Where:

fe = Equivalent flat plate area

$dCp/d\mu$ = Slope of coefficient of power versus advance ratio at a given coefficient of thrust

8. Changes in the equivalent flat plate area (Δfe) for various aircraft configurations were calculated by the following equation:

$$\Delta fe = \frac{2(\Delta C_P)A}{\mu^3} \quad (11)$$

Where:

Δfe = Change in flat plate area (ft^2)

ΔC_P = Change in coefficient of power

A = Main rotor disc area (ft^2)

Sawtooth Climbs and Autorotational Descent

9. A series of sawtooth climbs and autorotational descents were flown to determine the climb and autorotational descent performance. Zero sideslip and a constant rotor speed of 324 rpm was maintained for both climbs and descents. During climbs, the maximum power available commensurate with no rotor droop and other engine limitations was used. During autorotations, the throttle was adjusted to give zero torque. The rates of climb and descent (dH_P/dt) were determined from the rate of change of boom pressure altitude (Hp) with time, using the following equation:

$$R/C = \left(\frac{dH_P}{dt}\right)\frac{T_t}{Ts} \quad (12)$$

Where:

dHp/dt = Slope of pressure altitude versus time curve at a given pressure altitude (ft/min.). Hp was corrected for instrument and static system position error.

T_t = Test ambient air temperature at the pressure altitude at which the slope is taken (°K).

T_s = Standard ambient air temperature at the pressure altitude at which the slope is taken (°K).

10. Climb performance data were reduced to generalized parameters to provide a format for computing performance at any specified climb condition. The following parameters were used to generalize the climb data:

a. **Generalized power, variation from level flight:**

$$\Delta C_{P_{GEN}} = \frac{C_{P_C} - C_{P_L}}{0.707C_T^{1.5}} \quad (13)$$

b. **Vertical velocity ratio (VVR):**

$$VVR = \frac{V_v}{\Omega R\sqrt{C_T/2}} \quad (14)$$

c. **Forward velocity ratio (FVR):**

$$FVR = \frac{V_F}{\Omega R\sqrt{C_T/2}} \quad (15)$$

Where:

Cp_c = Climb power coefficient.

Cp_L = Level flight power coefficient.

V_V = Vertical velocity (ft/sec) = $\frac{dHp}{dt}/60$

V_F = Forward velocity (ft/sec) = $1.6878\ V_T\ 1 - (\frac{V_V}{1.6878V_T})^2$

V_T = Total boom true airspeed (kts)

11. Climb power for any condition can then be computed from the following equation by determining ΔCp_{GEN} as a function of the VVR and FVR required for the specific condition. The level flight power coefficient (Cp) should be obtained from the nondimensional level flight performance curves.

$$C_{P_c} = C_{P_L} + \Delta C_{P_{GEN}} \times 0.707C_T^{1.5} \quad (16)$$

12. The climb power correction coefficient (Kp) can be derived as function of dimensional and nondimensional terms as shown below:

a. **Dimensional:**

$$K_P = \frac{\Delta V_V}{\Delta SHP} \times \frac{GW}{550} \quad (17)$$

b. Nondimensional:

$$K_P = \frac{\Delta \mu_V}{\Delta C_{P_C}} \times C_T \tag{18}$$

Where:

μ_V = Vertical advance ratio - $V_V/\Omega R$

The averaged Kp of .8 for the clean configurations was obtained from reference 7, appendix A. For the MULTEWS configuration the average calculated Kp varied from .62 at a VVR of 4.1 to .8 at a VVR of 2.3.

13. The weight correction coefficient can be derived as a function of dimensional and nondimensional terms as shown below:

a. Dimensional:

$$K_W = \frac{\Delta V_v}{\Delta GW} \times \frac{GW^2}{550 \times SHP} \tag{19}$$

b. Nondimensional:

$$K_W = \frac{\Delta \mu v}{\Delta C_T} \times \frac{{C_T}^2}{C_P} \tag{20}$$

K_W for the clean and MULTEWS configuation is presented in figure 4 as a function of C_T.

Engine Inlet Exhaust Characteristics

14. Engine inlet and total temperature characteristics were obtained from figure 114 of USAASTA Report No. 66-04 (ref 7, app A). The exhaust losses of the Bell scoop IR suppressor were not measured, and the losses are assumed zero for the performance calculations of this report.

Shaft Horsepower Available and Specification Fuel Flow

15. Shaft horsepower available and specification fuel flow were obtained from Lycoming Engine Model Specification 104.33 by using computer program file number AE 03,00.23.00 dated 30 September 1969 (ref 8, app A), and the inlet characteristics described in paragraph 14.

FIGURE 4

VARIATION IN RATE OF CLIMB AS A FUNCTION OF THRUST COEFFICIENT

JUH-1H USA S/N 74-22538

MID CENTER OF GRAVITY

STANDARD DAY

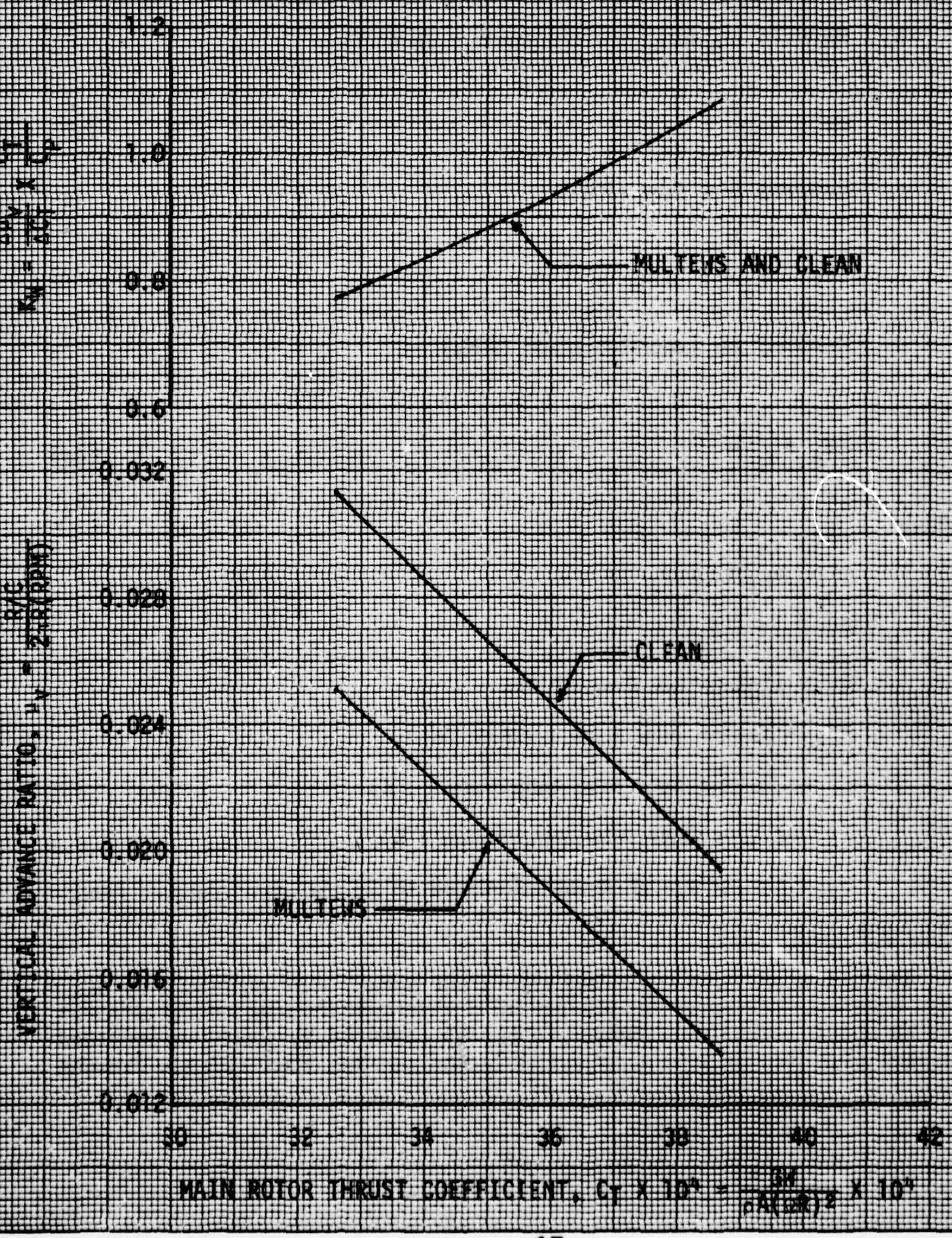
ALTITUDE = 5000 FEET

ROTOR SPEED = 324 RPM

POWER COEFFICIENT = .000261

NOTES: 1. CLIMB SPEED BASED ON FIG 2, APP C.

2. CURVES DERIVED FROM FIGS 3 AND 4, APP E.



16. The referred terms of the engine parameters were used to compare the test engine with the model specification engine. Data on shp, measured gas temperature (T_7), fuel flow, and gas generator speed (N_G) were referred as follows:

a. Referred shp (RSHP):

$$RSHP = \frac{SHP}{\delta_1\sqrt{\theta_1}} \tag{21}$$

b. Referred measured gas temperature (RMGT):

$$RMGT = \frac{T_7}{\theta_1} \tag{22}$$

c. Referred fuel flow (RW_f):

$$RW_f = \frac{W_f}{\delta_1\sqrt{\theta_1}} \tag{23}$$

d. Referred gas generator speed (RN_g):

$$RM_g = \frac{N_g}{\sqrt{\theta_1}} \tag{24}$$

Where:

$\delta_1 = P_{T_1}/14.697$

$\theta_1 = T_1/188.15$

W_f = Engine fuel flow (lb/hr)

P_{T_1} = Engine inlet total pressure (psi)

T_7 = Turbine inlet total temperature (°K)

T_1 = Engine inlet total temperature (°K)

N_g = Gas generator speed referenced to 25,150 rpm (percent rpm)

Pitot-Static Calibration

17. The boom and ship's standard pitot-static system were calibrated by using the trailing bomb and pace aircraft method to determine the airspeed and altimeter position error. Calibrated airspeed (V_{CAL}) was obtained by correcting indicated airspeed (V_i) for instrument error (ΔV_{ic}) and position error (ΔV_{P_c}). Pressure

altitude (Hp) was obtained by correcting indicated pressure altitude (Hp_i) for instrument error (ΔHp_{ic}) and position error (ΔHp_{p_c}). The boom airspeed calibration is included as figure 5. The altimeter position error (ΔHp_{p_c}) was calculated using ΔV_{P_c} and assuming all errors were introducted at the static port.

$$V_{CAL} = V_i + \Delta V_{ic} + \Delta V_{PC} \tag{25}$$

$$H_P = H_{P_i} + \Delta H_{P_{ic}} + \Delta H_{P_{pc}} \tag{26}$$

$$\Delta P_P = 1.4\, P_{a_O} \left(\frac{V_{ic}}{a_o}\right) \left[1 + 0.2 \left(\frac{V_{ic}}{a_o}\right)^2\right]^{2.5} \left(\frac{\Delta V_{Pc}}{a_o}\right) \tag{27}$$

$$+ 0.7 P_{a_o} \left[1 + 0.2 \left(\frac{V_{ic}}{a_o}\right)^2\right]^{1.5} \left[1 + 1.2 \left(\frac{V_{ic}}{a_o}\right)^2\right] \left(\frac{\Delta V_{pc}}{a_o}\right)^2$$

$$\Delta H_{P_{pc}} = \left[1 - \left(\frac{\Delta P_P}{P_{a_o}}\right)^{1/5.255863}\right] / 6.8755856E-06 \tag{28}$$

Where:

σ_S = Density ratio at the indicated pressure altitude corrected for instrument error.

V_{ic} = Indicated airspeed corrected for instrument error.

a_{SL} = Speed of sound at sea level (kt).

Weight and Balance

18. The aircraft weight, longitudinal cg location, and lateral cg location were determined prior to testing, and checked periodically throughout the tests. The initial weighing included a fuel cell calibration. All weighings were accomplished with instrumentation installed. The aircraft was ballasted as necessary to achieve the desired takeoff gross weight and cg.

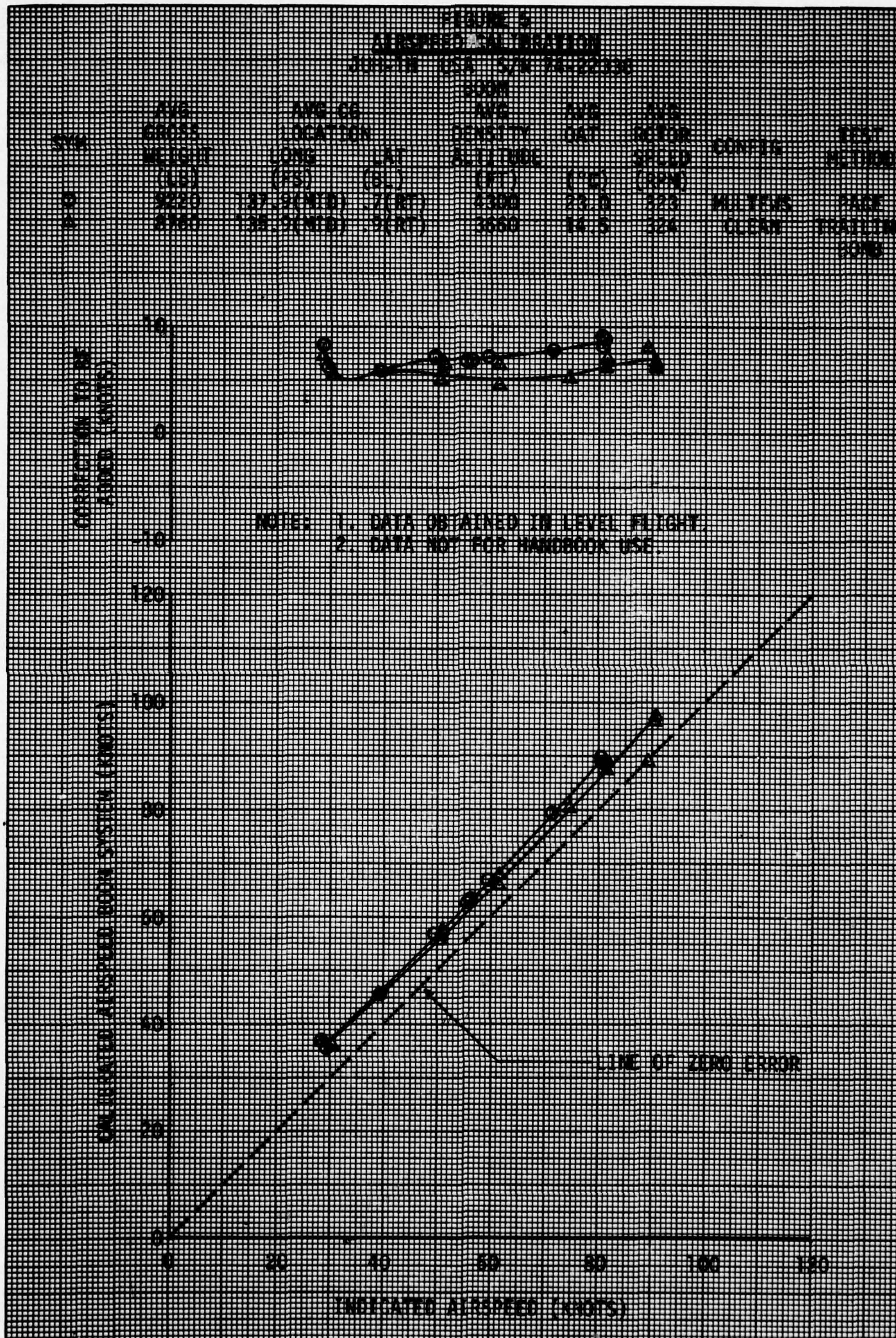


FIGURE 5
AIRSPEED CALIBRATION
BOOM
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (°C)
AVG ROTOR SPEED (RPM)
CONFIG
TEST METHOD
323
324
CLEAN
PACE
TRAILING BOMB
CORRECTION TO BE ADDED (KNOTS)
10
0
-10
NOTE: 1. DATA OBTAINED IN LEVEL FLIGHT.
2. DATA NOT FOR HANDBOOK USE.
CALIBRATED AIRSPEED BOOM SYSTEM (KNOTS)
120
100
80
60
40
20
0
LINE OF ZERO ERROR
0
20
40
60
80
100
120
INDICATED AIRSPEED (KNOTS)

19. The fuel loading for each test flight was determined prior to engine start and following engine shutdown by using a calibrated sight gage to determine fuel volume and by measuring specific gravity. Fuel used in flight was recorded by a sensitive fuel-flow system and verified with the pre- and postflight sight gage readings.

Control System Characteristics

20. The mechanical characteristics of the control system were evaluated on the ground with the rotor and engine stopped. Hydraulic and electrical power were provided by external sources. Control forces were measured by use of a hand-held force gage applied at the center of the cyclic control grip and directional pedals. All switches and systems were set to duplicate normal in-flight conditions. All pilot-adjusted friction levels were set to their minimum values. Control displacements from the neutral trim point were then plotted as a function of force.

Control Positions in Trimmed Forward Flight

21. Control positions in trimmed forward flight were evaluated from data obtained during level flight performance testing at stabilized trimmed points. Data were recorded on a magnetic flight tape. The control positions were plotted as a function of airspeed.

Low-Speed Flight Characteristics

22. Low-speed flight characteristics were evaluated by using a calibrated pace vehicle on a hard-surfaced runway. The evaluation was conducted under wind conditions of less than 3 knots. Accurate wind measurements were recorded for all points, using portable wind measuring equipment so that data could be corrected to a zero wind condition. The pace vehicle was driven at constant speed with the test aircraft flying "formation" at a constant skid height of 10 feet. Control positions, control displacements (pilot effort), aircraft attitudes, and performance parameters were recorded on magnetic tape. The ground speed read-out from the mission equipment doppler navigation system (AN/APN-128) was also recorded on magnetic tape and showed excellent agreement with pace vehicle speeds.

23. The control positions, with indications for control displacement, were plotted as a function of airspeed for low-speed forward and rearward as well as left and right sideward flight. Qualitative pilot comments and the Handling Qualities Rating Scale were used to evaluated the low-speed flight regime.

Static Longitudinal Stability

24. Static longitudinal stability was evaluated in level, climbing, and autorotational flight. The aircraft was trimmed at the desired trim airspeed. With collective fixed, the aircraft was stabilized at approximately 5-knot increments ±20 knots from trim airspeed, allowing altitude, rate of climb, or rate of descent to vary as necessary. Control positions and airspeeds were recorded on magnetic tape. The control positions were then plotted as a function of calibrated airspeed.

Static Lateral-Directional Stability

25. This test was conducted using the steady-heading sideslip method and was accomplished by establishing a trimmed flight condition and then stabilizing at incremental sideslip angles, in 5-degree increments, to the limit of the flight envelope or until full control deflection was reached, whichever occurred first. Collective control position was fixed at the trim value and altitude was allowed to vary. Cross-controlling was used as necessary to maintain the trim airspeed and desired heading. All pertinent parameters were recorded on magnetic tape. The static directional stability, dihedral effect, and side-force characteristics of the aircraft were evaluated by plotting the variation of control position and aircraft attitude with sideslip angle.

Maneuvering Stability

27. Dynamic stability tests were conducted to evaluate the short and long-period response characteristics of the aircraft. Short-period characteristics were evaluated to determine aircraft response to sudden wind gusts and were simulated by rapidly displacing the cyclic or directional control approximately 1 inch, holding the input for 0.5 second, then rapidly returning the control to the trim position while recording the resulting aircraft responses on magnetic tape.

28. Long-period characteristics were evaluated to determine the aircraft's tendency to return to a trim condition after being disturbed. The long-period response was excited by stabilizing the aircraft at a trim condition with force trim ON and then displacing the longitudinal control forward or aft to effect an airspeed change of approximately 10 knots. The control was then returned to trim and the resulting aircraft response was recorded on magnetic tape. During the response, controls were held fixed, but slight pressures directionally and laterally were used to maintain a no-turn condition The long-period response was evaluated at two trim airspeeds and a positive and negative airspeed change was tested for each point.

29. Dynamic lateral-directional stability was tested to determine the lateral-directional damping and Dutch-roll characteristics of the aircraft. The technique employed was a sudden release from left or right steady-heading sideslip. Aircraft response was recorded on magnetic tape.

Simulated Engine Failures

30. Autorotational entries were evaluated by stabilizing the aircraft at the desired condition, then simulating an engine failure by rapidly retarding the throttle to flight-idle. The controls were held fixed for 3 seconds (2 seconds for H-V testing) or until the predetermined limits of 30 degrees pitch, 30 degrees yaw, 60 degrees roll, or a minimum rotor speed of 250 rpm was reached, whichever occurred first.

31. The test technique used to enter autorotation during the H-V testing was the same as the technique used during the autorotational entry evaluation. The tests were conducted in the following manner: (1) landing gross weight was increased from 8700 lbs to 9300 lbs in 200 lb increments. Ballast was added between landings to maintain gross weight within 50 lbs of the aim landing gross weight. During this part of the buildup, entry airspeed (65 KIAS) and entry altitude (400 ft AGL) were held constant; (2) entry airspeed was incrementally decreased

from 65 to 50 KIAS in 5 kt increments while maintaining a 9300 lb landing gross weight and a 400 ft AGL entry altitude; (3) entry altitude was decreased from 400 to 375 ft AGL while maintaining the 9300 lb landing gross weight and 50 KIAS entry airspeed. No attempt was made during the evaluation to perform zero ground speed landings. The test technique used was to transition from an autorotational attitude to a decelerational attitude at approximately 300 ft AGL, hold the deceleration attitude until the aircraft was near 150 ft AGL, make the initial collective pitch application, level the aircraft, and use the remainder of the collective pitch to cushion the landing.

APPENDIX E. TEST DATA

INDEX

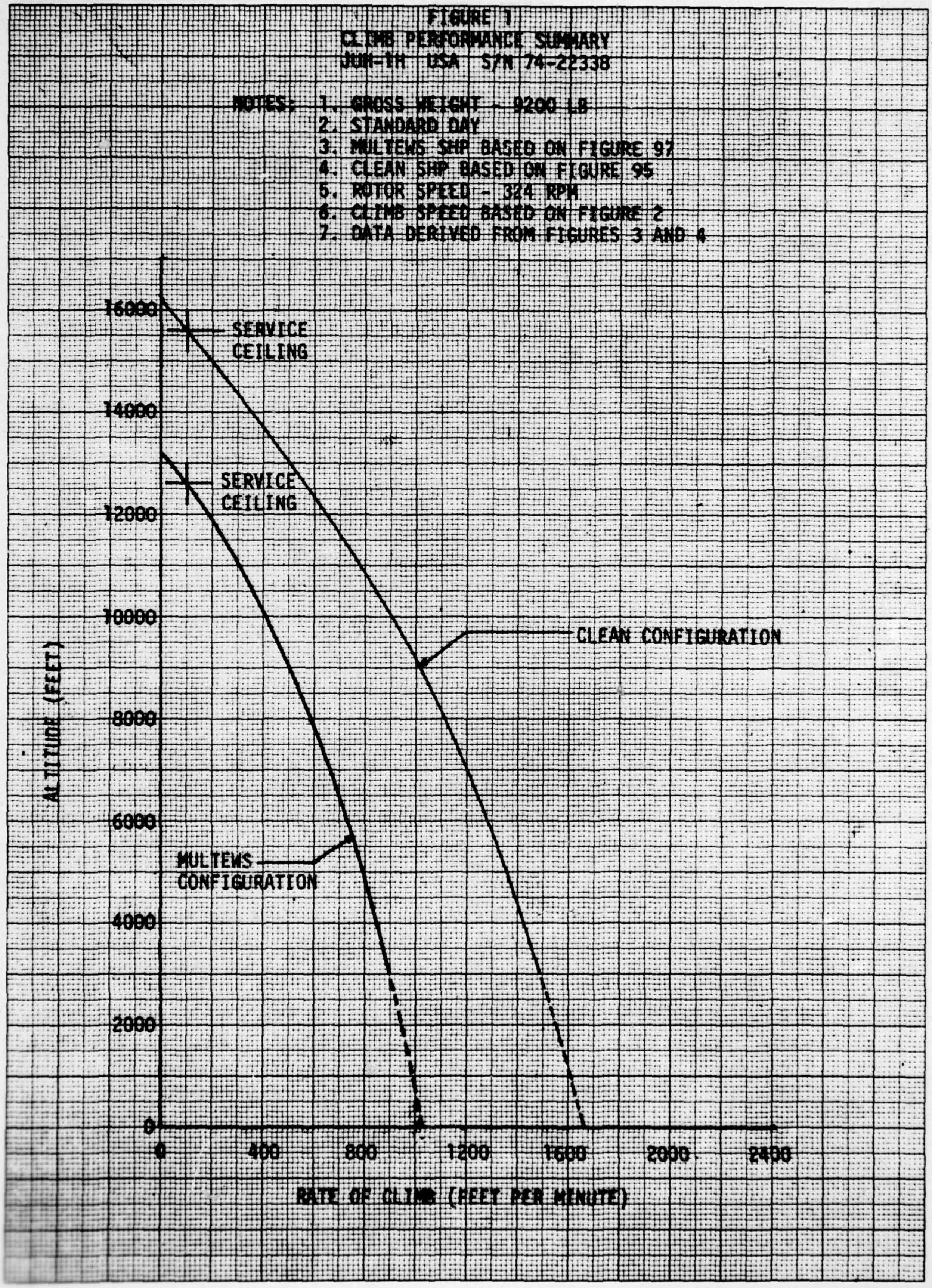


FIGURE 1
CLIMB PERFORMANCE SUMMARY
JUH-1H USA S/N 74-22338
NOTES: 1. GROSS WEIGHT - 9200 LB
2. STANDARD DAY
3. MULTEWS SHP BASED ON FIGURE 97
4. CLEAN SHP BASED ON FIGURE 95
5. ROTOR SPEED - 324 RPM
6. CLIMB SPEED BASED ON FIGURE 2
7. DATA DERIVED FROM FIGURES 3 AND 4
SERVICE CEILING
SERVICE CEILING
CLEAN CONFIGURATION
MULTEWS CONFIGURATION
ALTITUDE (FEET)
0
2000
4000
6000
8000
10000
12000
14000
16000
0
400
800
1200
1600
2000
2400
RATE OF CLIMB (FEET PER MINUTE)

FIGURE 2
CLIMB SPEED SCHEDULE
JUH-1H USA S/N 74-22338
GROSS WEIGHT = 9200 LB
ROTOR SPEED = 324 RPM
STANDARD DAY

NOTE: DATA OBTAINED FROM FIGURES 3 AND 4

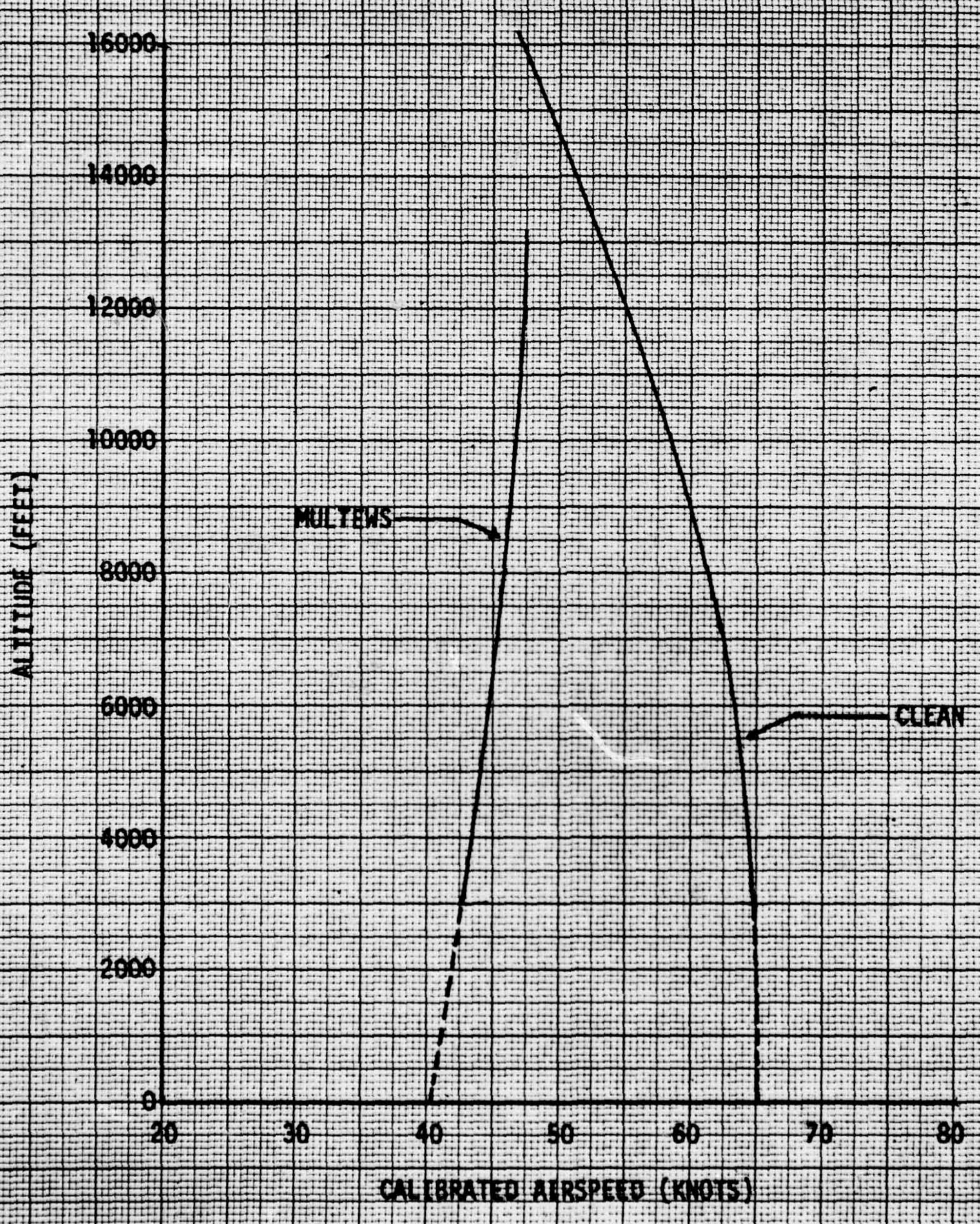


FIGURE 3
GENERALIZED CLIMB AND DESCENT PERFORMANCE
JUH-1H USA S/N 74-22338

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG OAT (°C)	AVG REFERRED ROTOR SPEED (RPM)	AVG C_T	FORWARD VELOCITY RATIO
○	9080	135.8(MID)	0.8	11.0	316	0.004225	2.1
□	9220	137.0(MID)	0.8	13.5	323	0.004142	2.7
△	9220	137.4(MID)	0.7	15.5	317	0.004193	3.3
◇	9180	137.0(MID)	0.7	16.5	316	0.004189	3.9
▽	9180	137.8(MID)	0.7	16.5	312	0.004124	4.5

NOTES: 1. CLEAN CONFIGURATION
2. C_{P_L} BASED ON FIGURES 5 AND 6

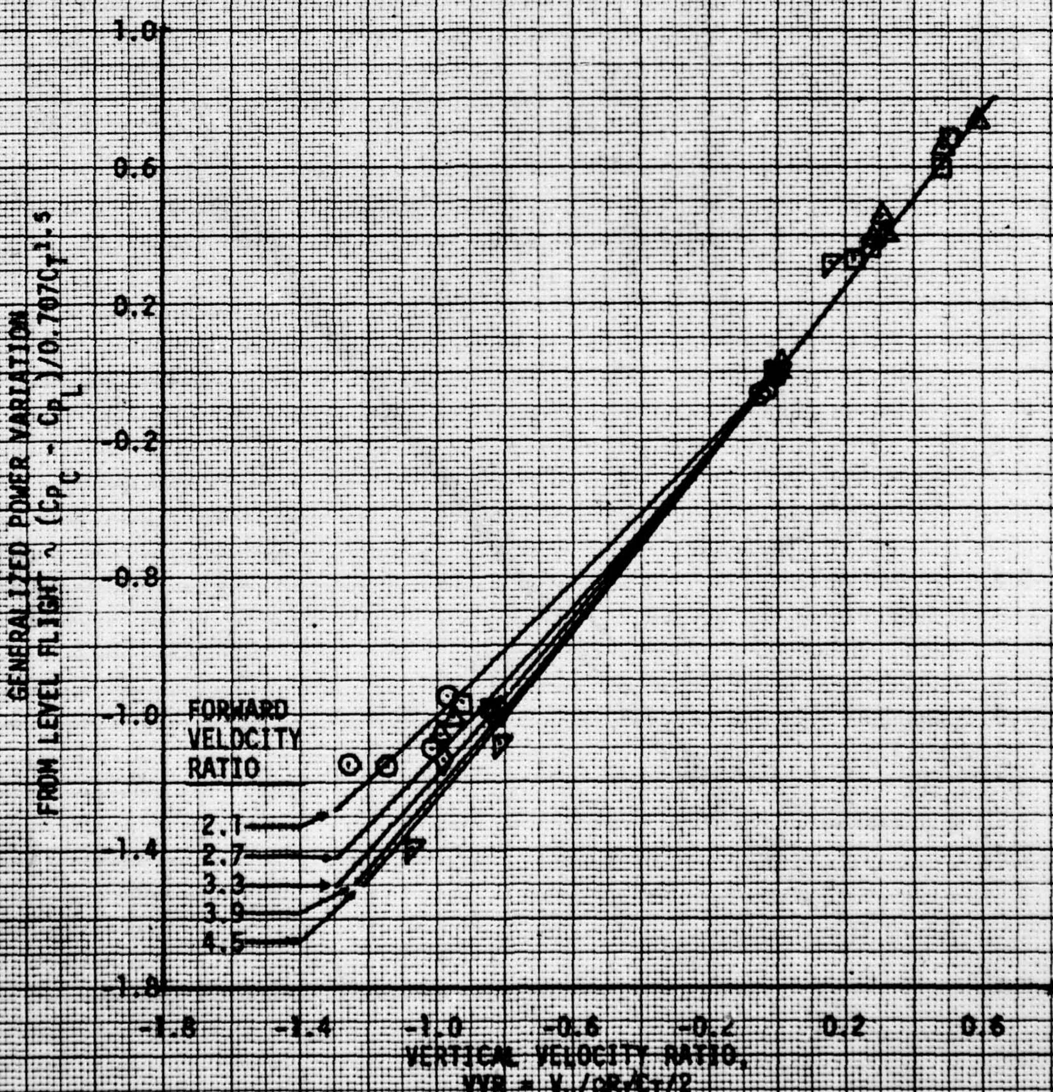
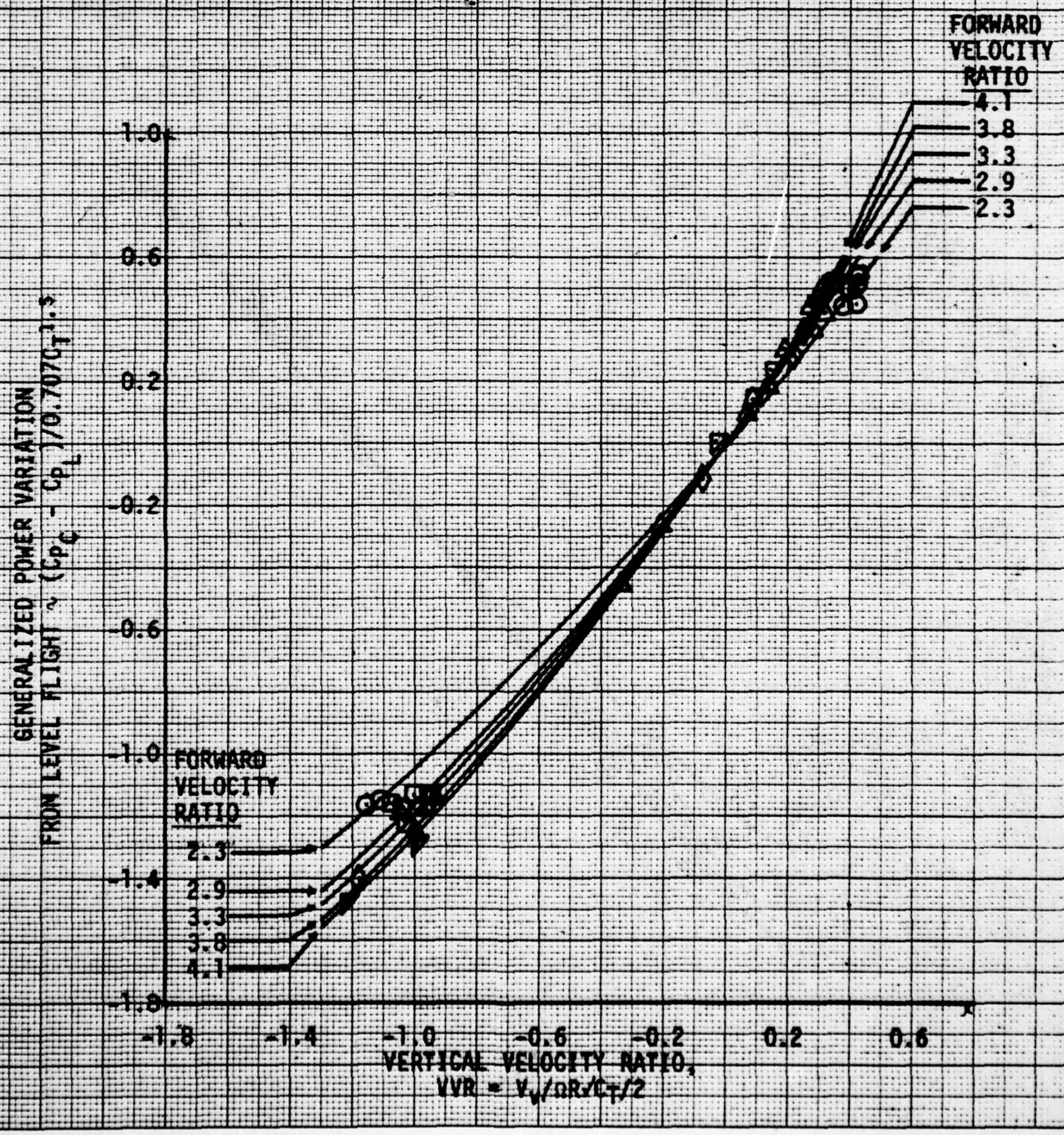


FIGURE 4
GENERALIZED CLIMB AND DESCENT PERFORMANCE
JUH-1H USA S/N 74-22338

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FORWARD VELOCITY RADIO
○	9060	136.0(MID)	0.7	23.0	319	0.003779	2.3
□	9120	136.4(MID)	0.7	23.5	318	0.003806	2.9
△	9140	136.6(MID)	0.7	25.0	317	0.003805	3.3
◇	9000	135.8(MID)	0.7	24.0	319	0.003781	3.8
▽	9000	135.8(MID)	0.7	22.5	319	0.003734	4.1

NOTES: 1. MULTEWS CONFIGURATION
2. C_{P_L} BASED ON FIGURES 7 AND 8.



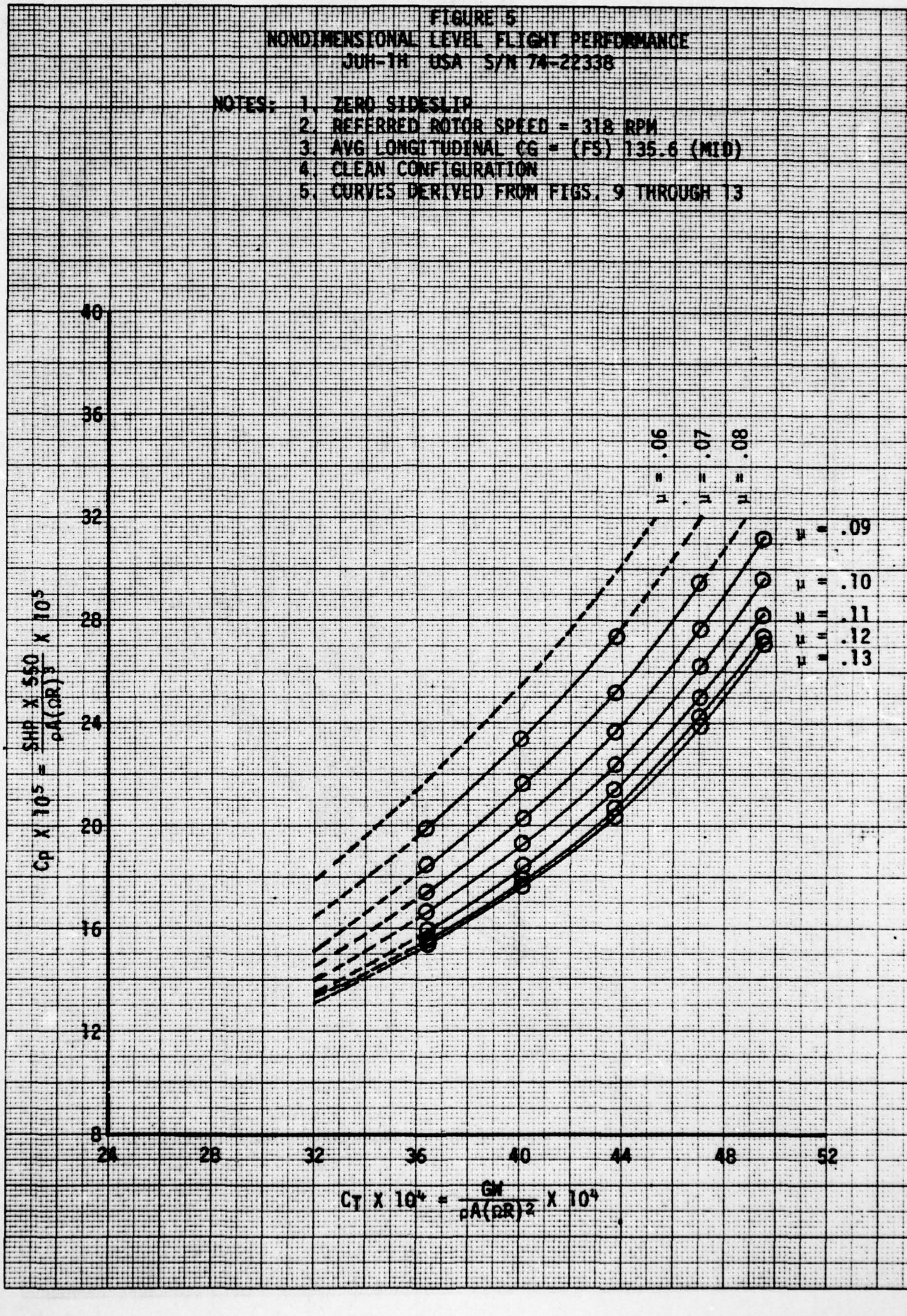


FIGURE 5
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338
NOTES: 1. ZERO SIDESLIP
2. REFERRED ROTOR SPEED = 318 RPM
3. AVG LONGITUDINAL CG = (FS) 135.6 (MID)
4. CLEAN CONFIGURATION
5. CURVES DERIVED FROM FIGS. 9 THROUGH 13
μ = .06
μ = .07
μ = .08
μ = .09
μ = .10
μ = .11
μ = .12
μ = .13
$C_P \times 10^5 = \frac{SHP \times 550}{\rho A(\Omega R)^3} \times 10^5$
$C_T \times 10^4 = \frac{GW}{\rho A(\Omega R)^2} \times 10^4$
8
12
16
20
24
28
32
36
40
24
28
32
36
40
44
48
52

FIGURE 6
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

NOTES: 1. ZERO SIDESLIP
2. REFERRED ROTOR SPEED = 318 RPM
3. AVG LONGITUDINAL CG = (FS) 135.6 (MID)
4. CLEAN CONFIGURATION
5. CURVES DERIVED FROM FIGS. 9 THROUGH 13

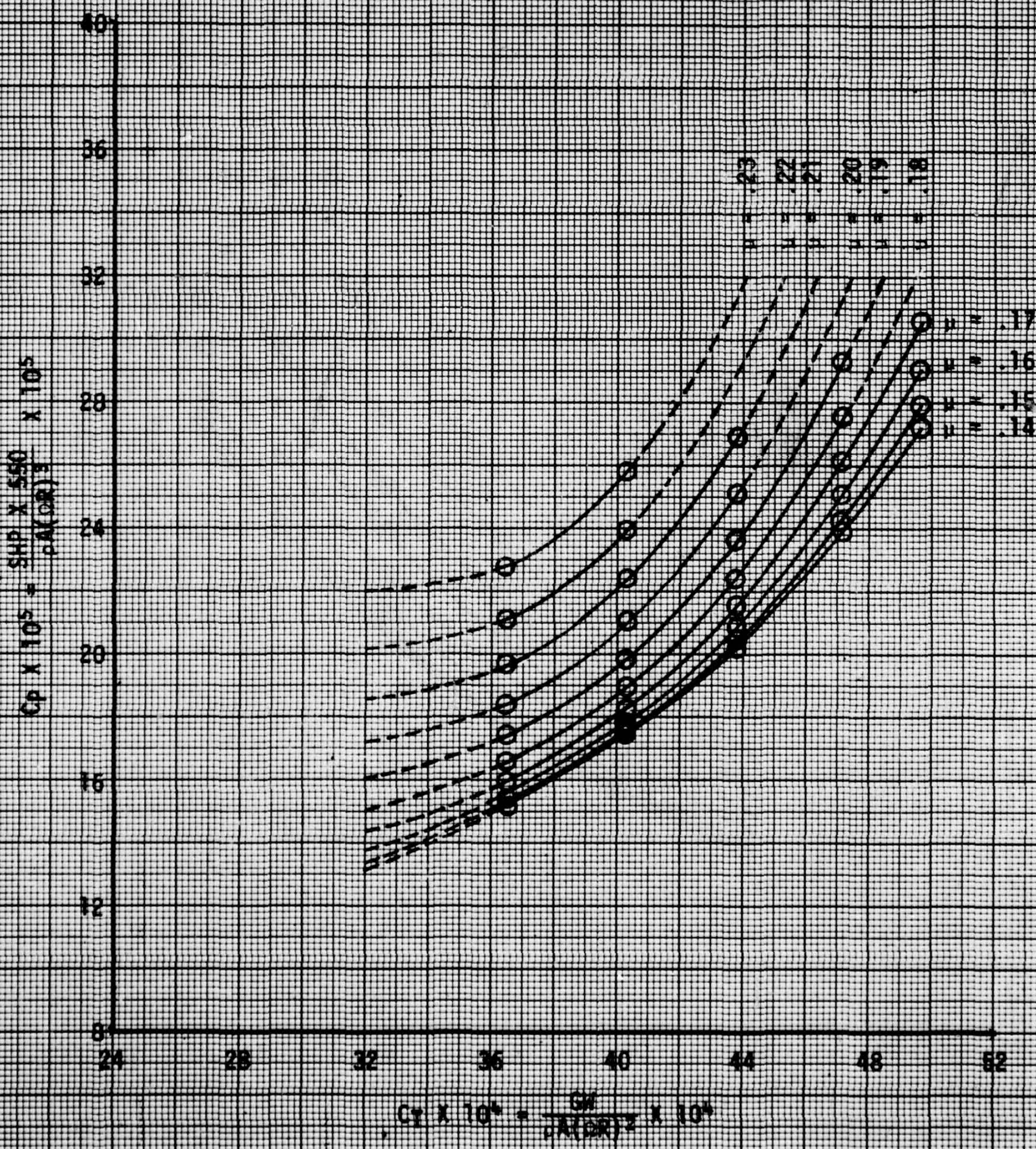


FIGURE 7
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

NOTES:
1. ZERO SIDESLIP
2. REFERRED ROTOR SPEED = 318 RPM
3. AVG LONGITUDINAL CG = (FS) 135.3 (MID)
4. MULTEWS CONFIGURATION
5. CURVES DERIVED FROM FIGS. 14 THROUGH 18.

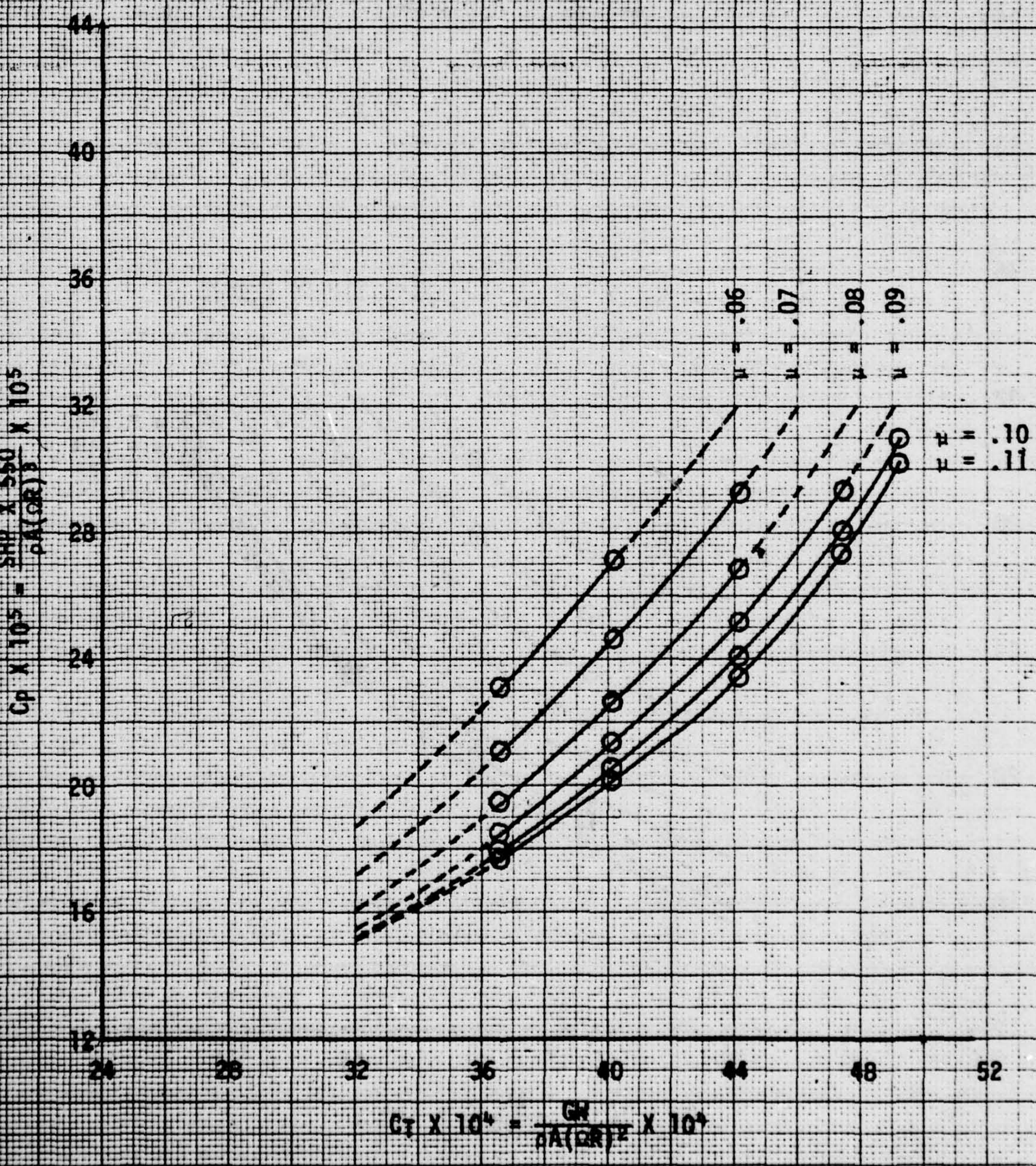


FIGURE 8
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

NOTES: 1. ZERO SIDESLIP
2. REFERRED ROTOR SPEED = 318 RPM
3. AVG LONGITUDINAL CG = (FS) 135.3 (MID)
4. MULTEWS CONFIGURATION
5. CURVES DERIVED FROM FIGS. 14 THROUGH 18.

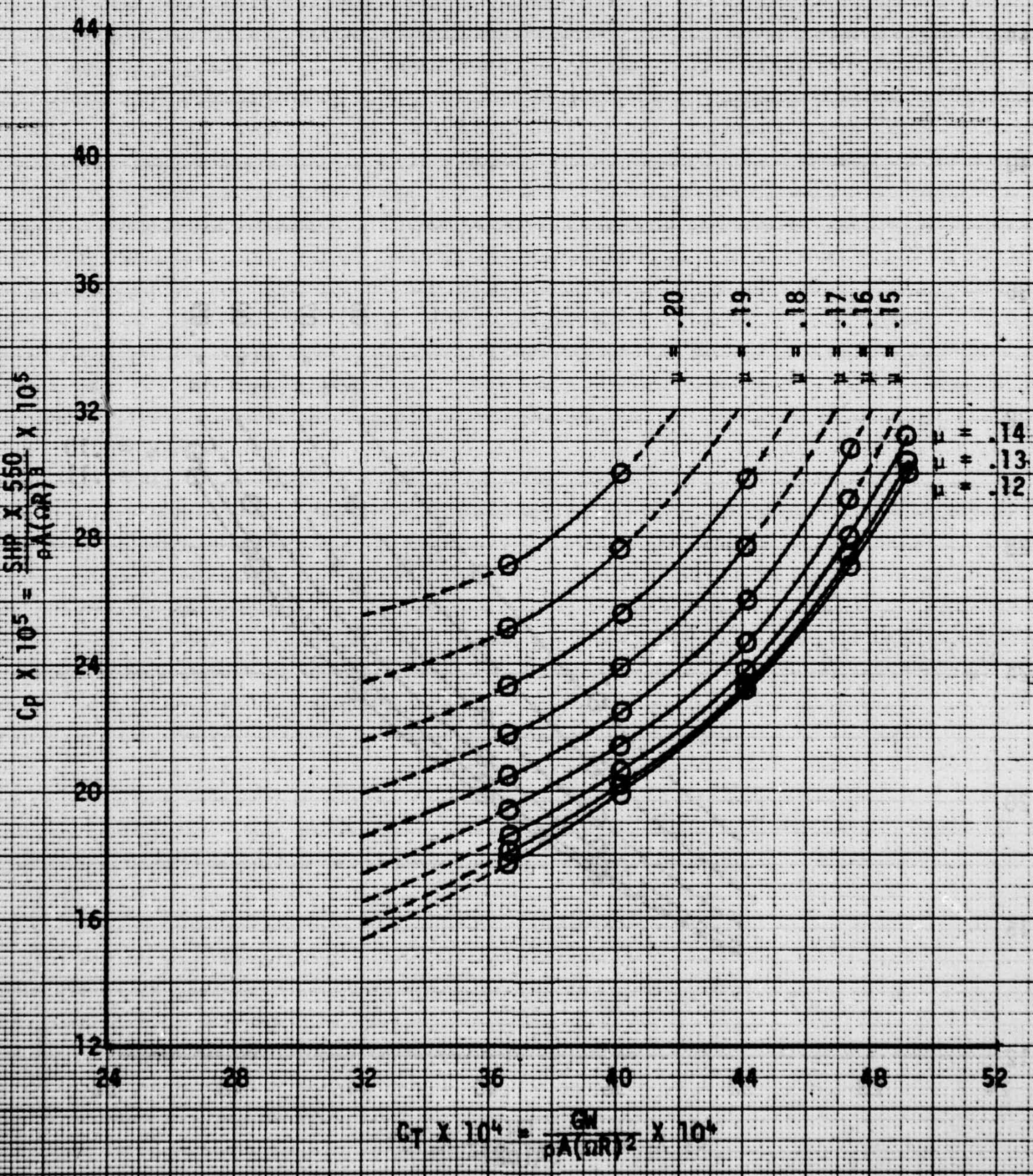


FIGURE 9
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

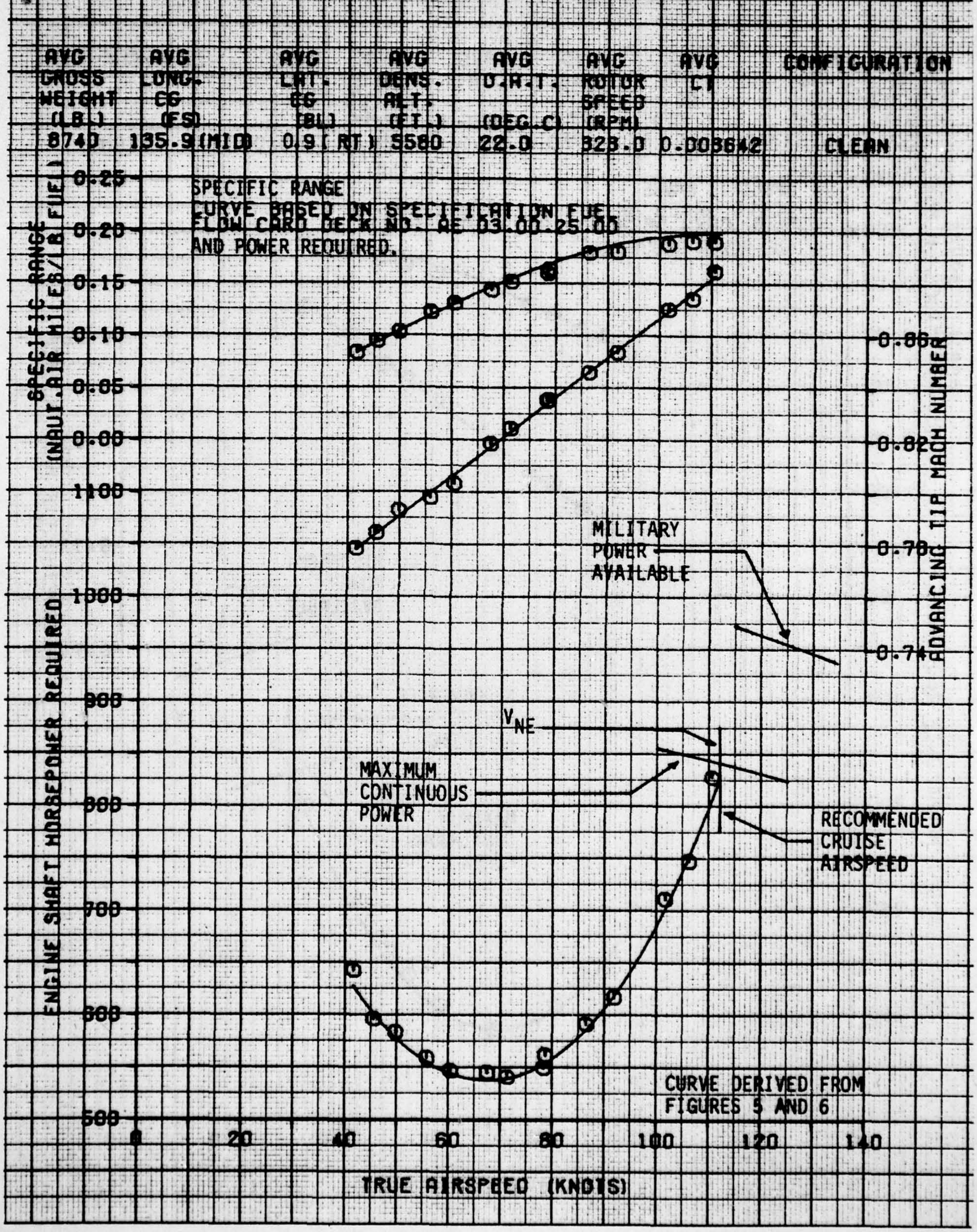


FIGURE 10
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG LONG. CG (FS)	AVG LAT. CG (BL)	AVG DENS. ALT. (FT)	AVG O.A.T. (DEG.C)	AVG ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
9180	135.6 (MID)	0.9 (RT)	6760	20.0	321.0	0.004015	CLEAN

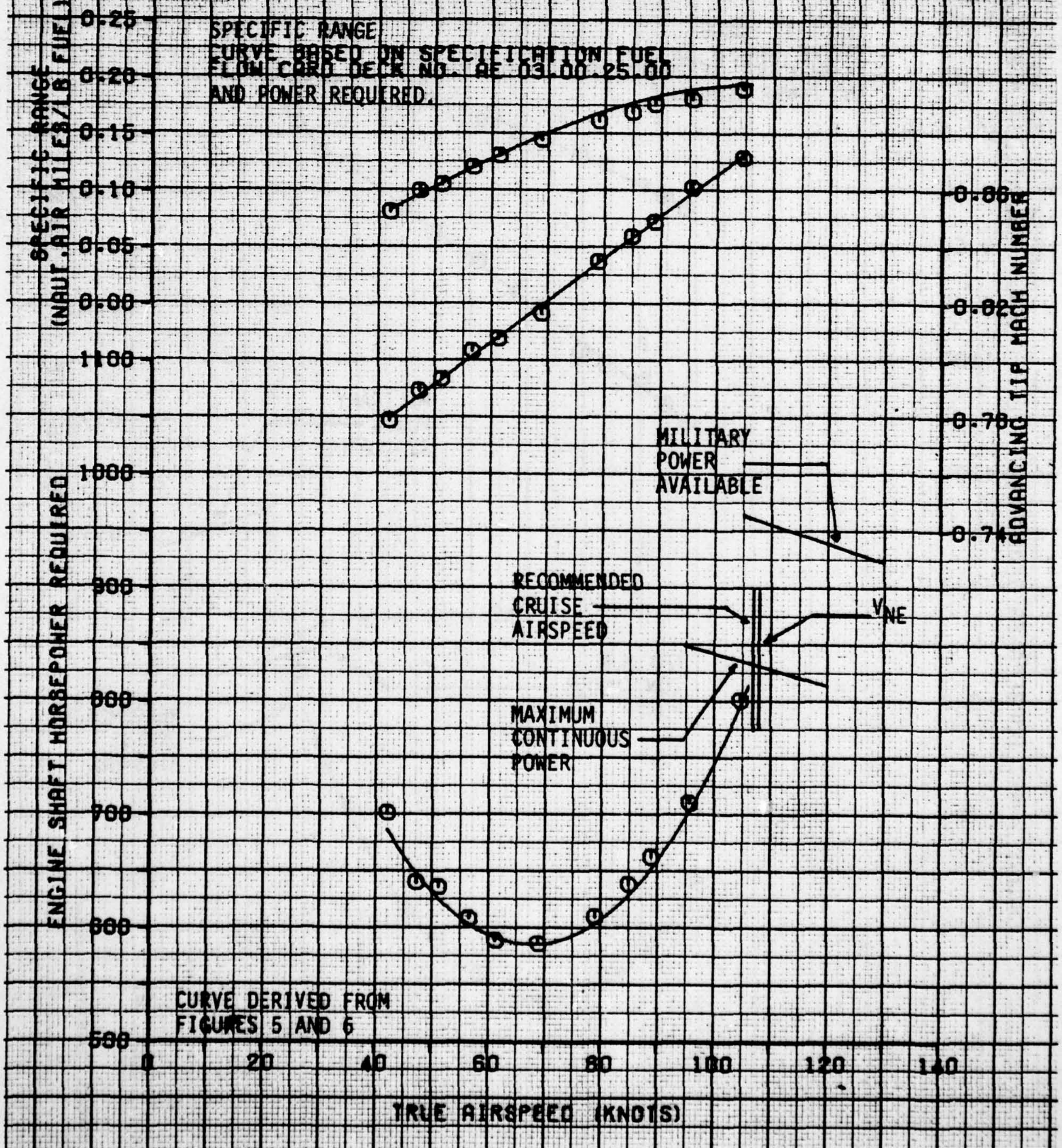


FIGURE 11
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG LONG. CG (FS)	AVG LAT. CG (BL)	AVG DENS. ALT. (FT)	AVG O.A.T. (DEG C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIGURATION
9140	135.5(MID)	0.9(RT)	9680	20.5	321.0	0.004377	CLEAN

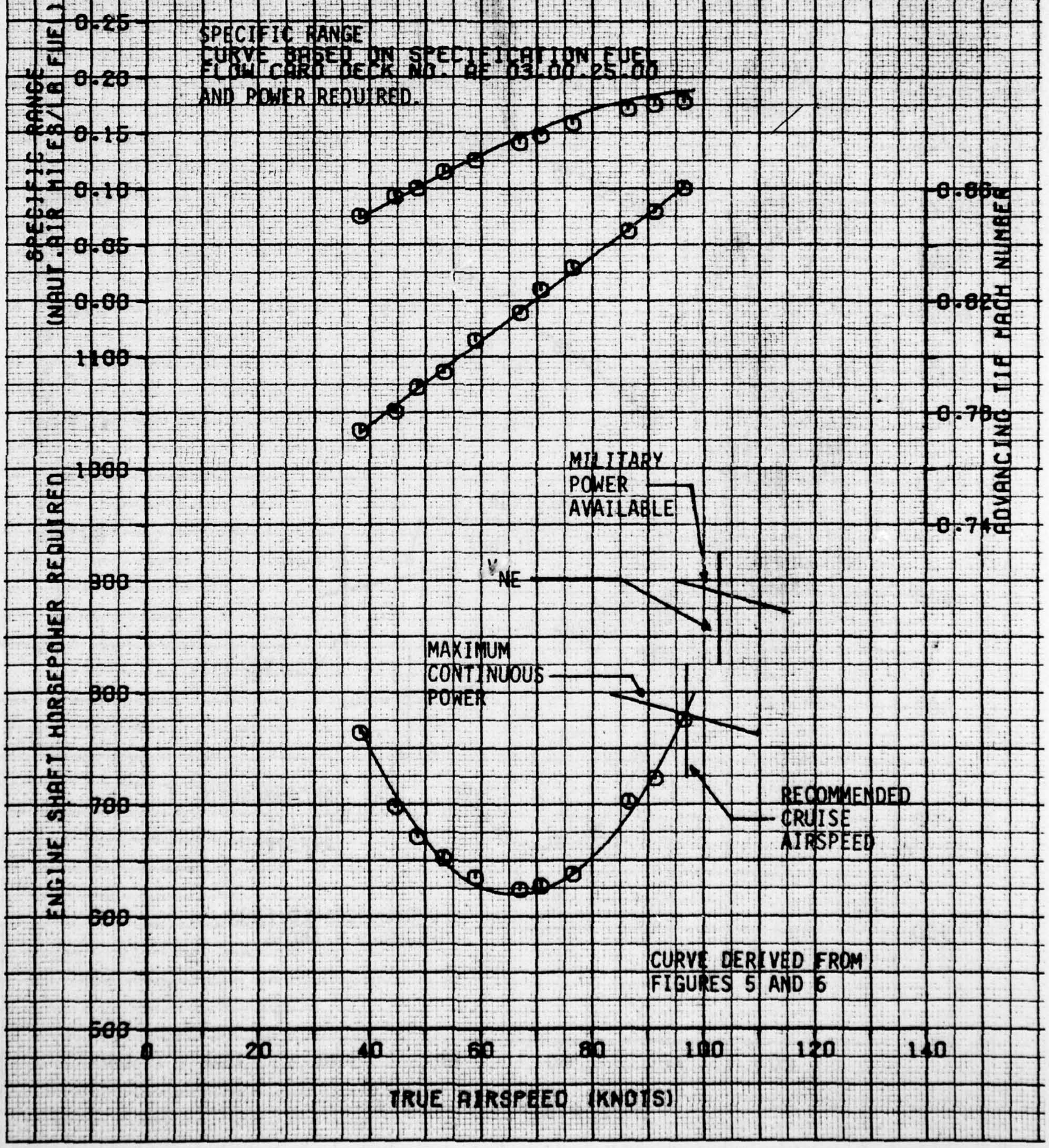


FIGURE 12

LEVEL FLIGHT PERFORMANCE

JUH-1H USA S/N [illegible]-22538

AVG GROSS WEIGHT (LB)	AVG LONG. CG (FS)	AVG LAT. CG (BL)	AVG DENS. ALT. (FT)	AVG O.A.T. (DEG. C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIGURATION
9180	135.6(MID)	0.9(RT)	10880	11.5	316.0	0.004711	CLEAN

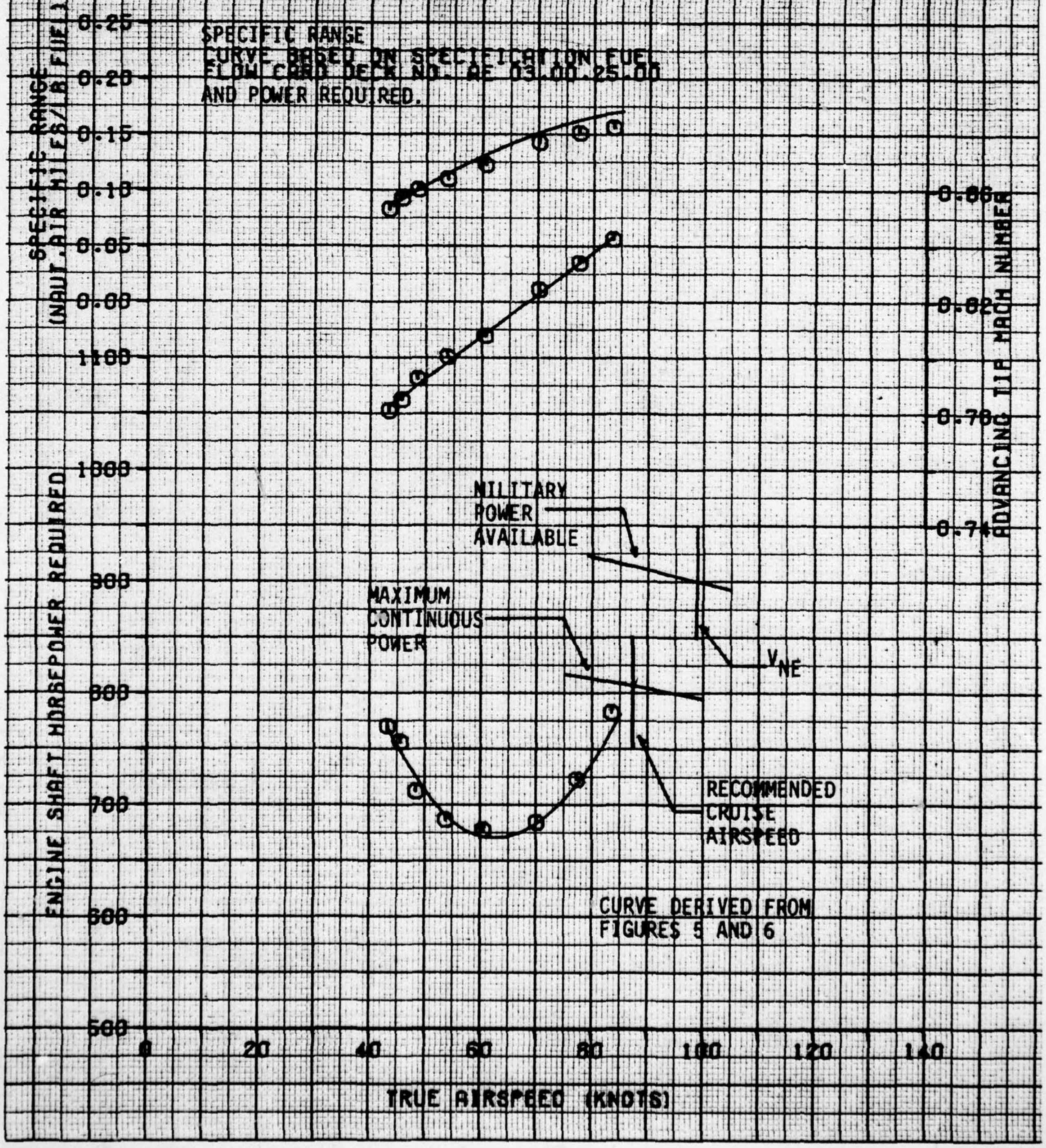
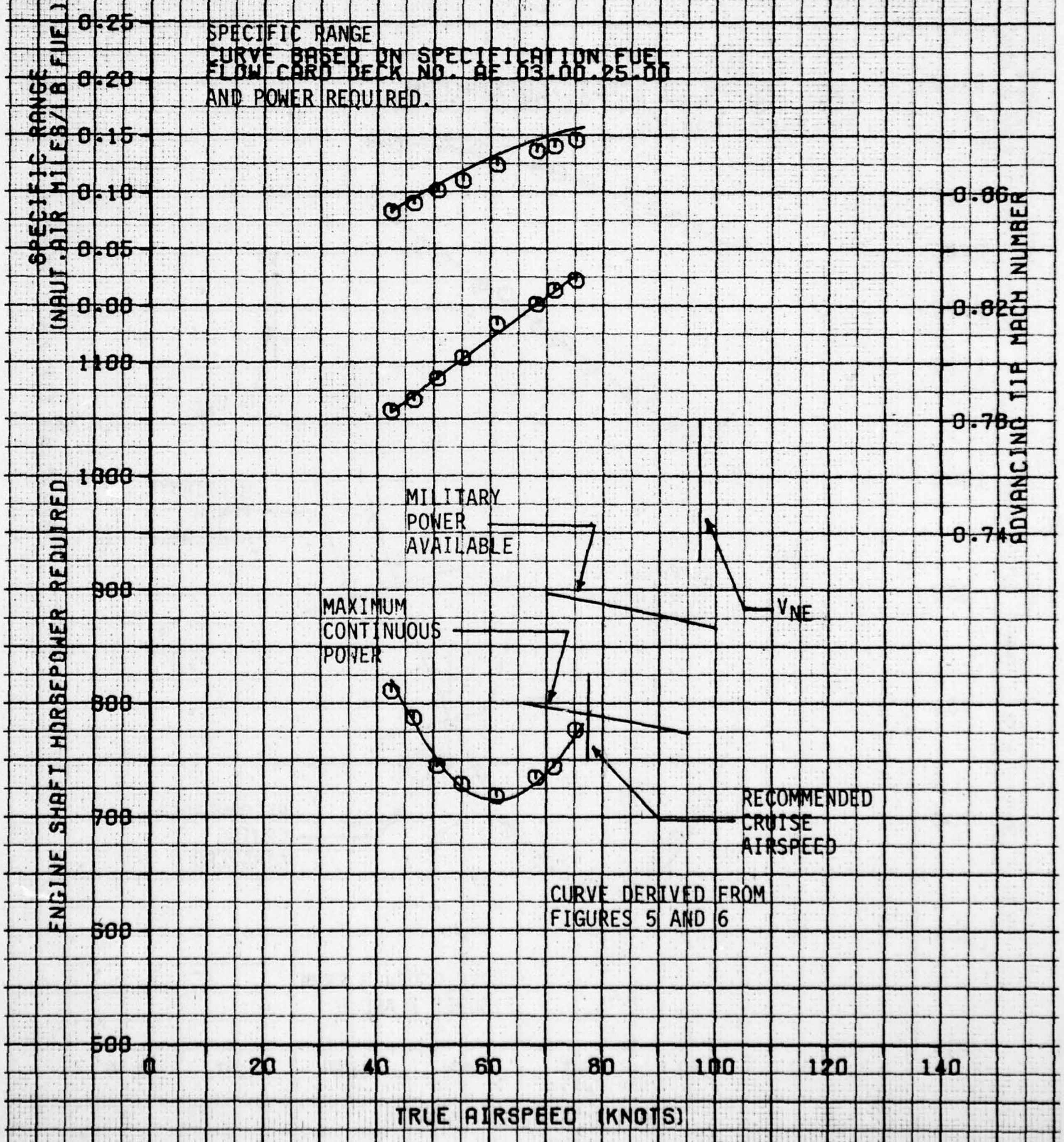


FIGURE 13
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG LONG. CG (FS)	AVG LAT. CG (BL)	AVG DENS. ALT. (FT.)	AVG O.A.T. (DEG.C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIGURATION
9120	135.3(MID)	0.9(RT)	12520	8.0	315.0	0.004962	CLEAN



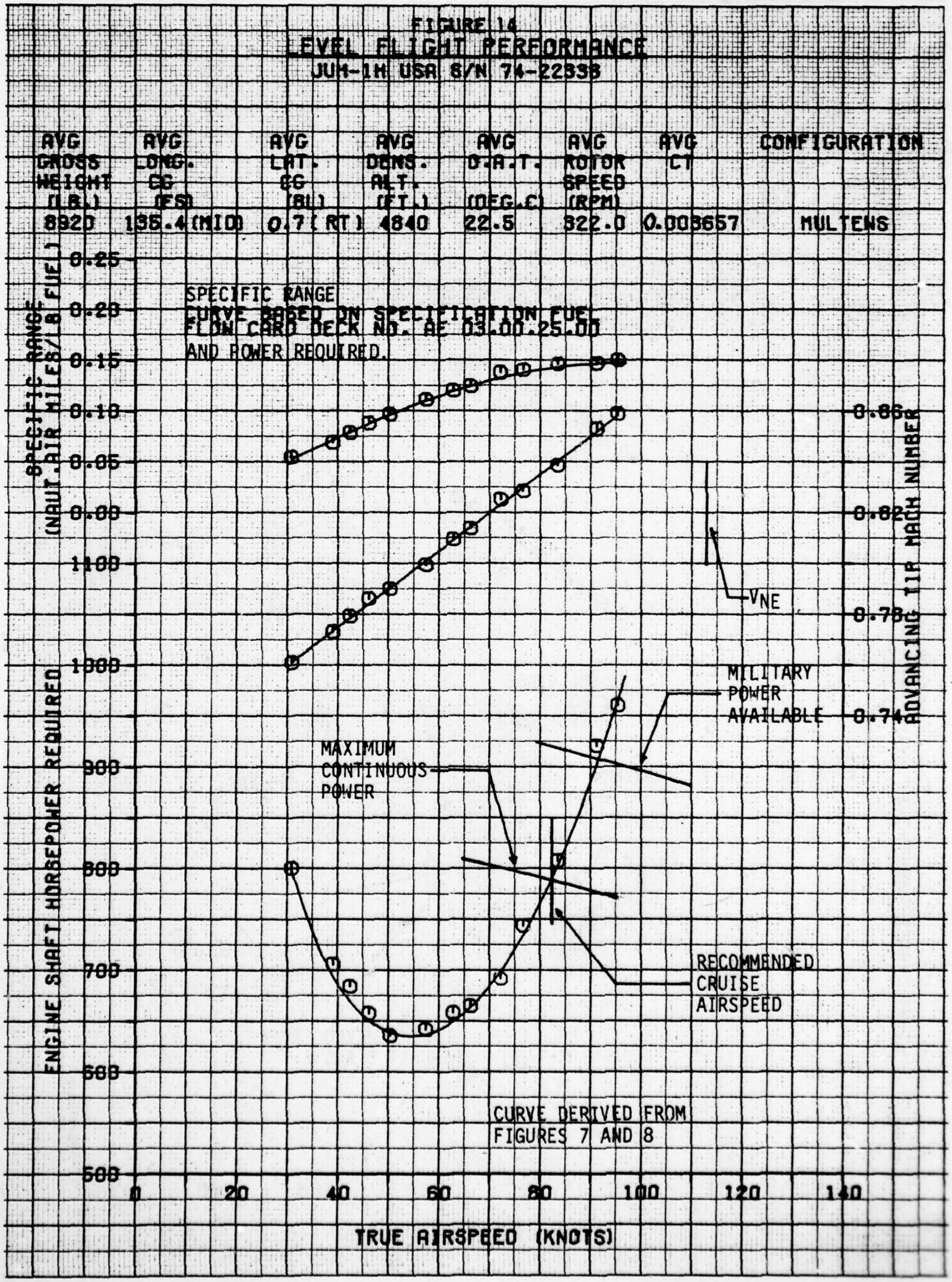
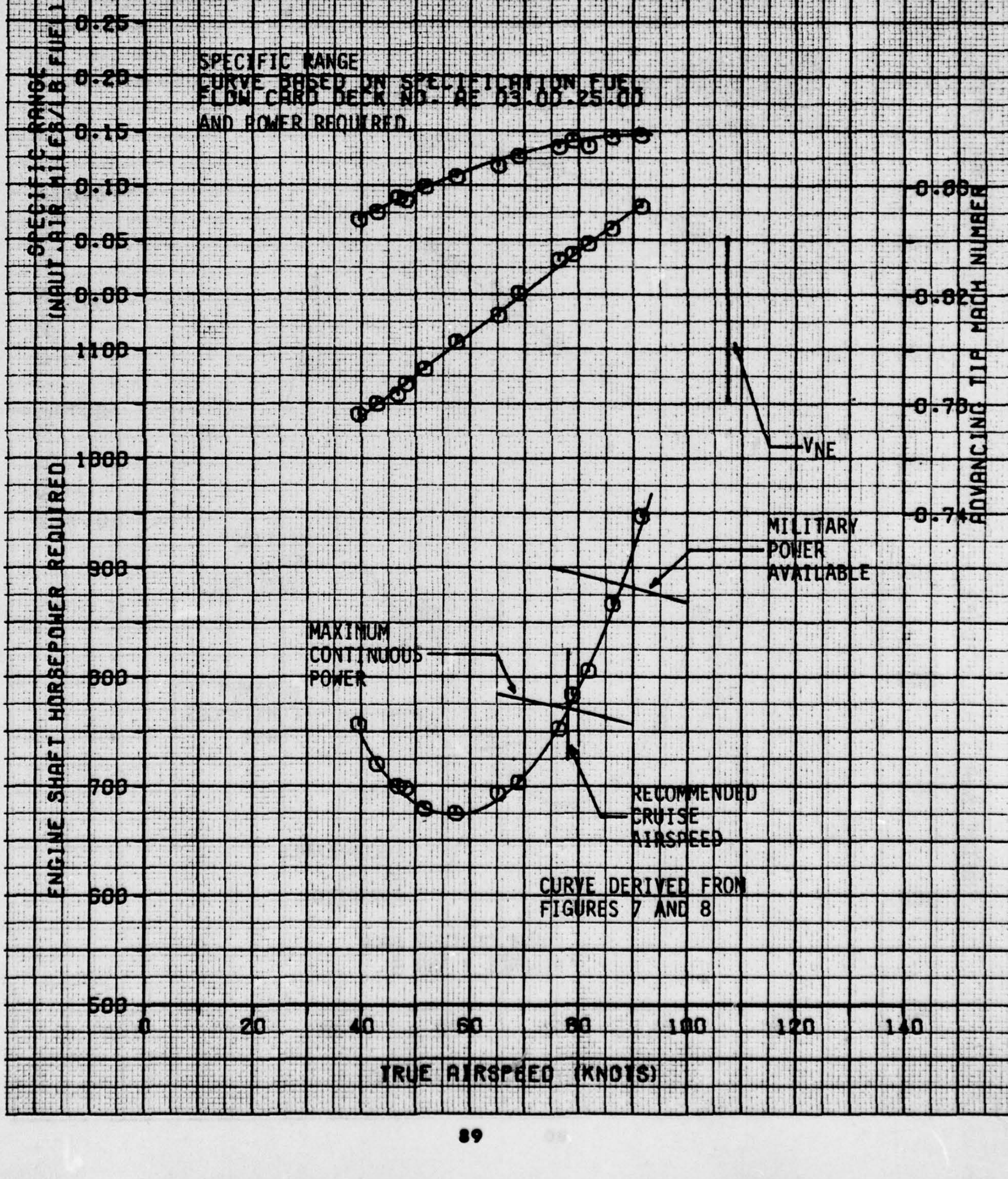


FIGURE 16
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338
AVG GROSS WEIGHT (LB.) 8920
AVG LONG. CG (FS) 135.4 (MID)
AVG LAT. CG (BL) 0.7 (RT)
AVG DENS. ALT. (FT.) 4840
AVG O.A.T. (DEG.C) 22.5
AVG ROTOR SPEED (RPM) 322.0
AVG CT 0.003657
CONFIGURATION MULTENS
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
SPECIFIC RANGE
CURVE BASED ON SPECIFICATION FUEL FLOW CARD DECK NO. AE 03.00.25.00
AND POWER REQUIRED.
ADVANCING TIP MACH NUMBER
V_{NE}
MILITARY POWER AVAILABLE
MAXIMUM CONTINUOUS POWER
RECOMMENDED CRUISE AIRSPEED
ENGINE SHAFT HORSEPOWER REQUIRED
CURVE DERIVED FROM FIGURES 7 AND 8
TRUE AIRSPEED (KNOTS)

FIGURE 15
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB.)	AVG LONG. CG (FS)	AVG LAT. CG (BL)	AVG DENS. ALT. (FT.)	AVG O.A.T. (DEG.C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIGURATION
9200	135.8(MID)	0.7(RT)	6660	19.5	321.0	0.004012	MULTEWS



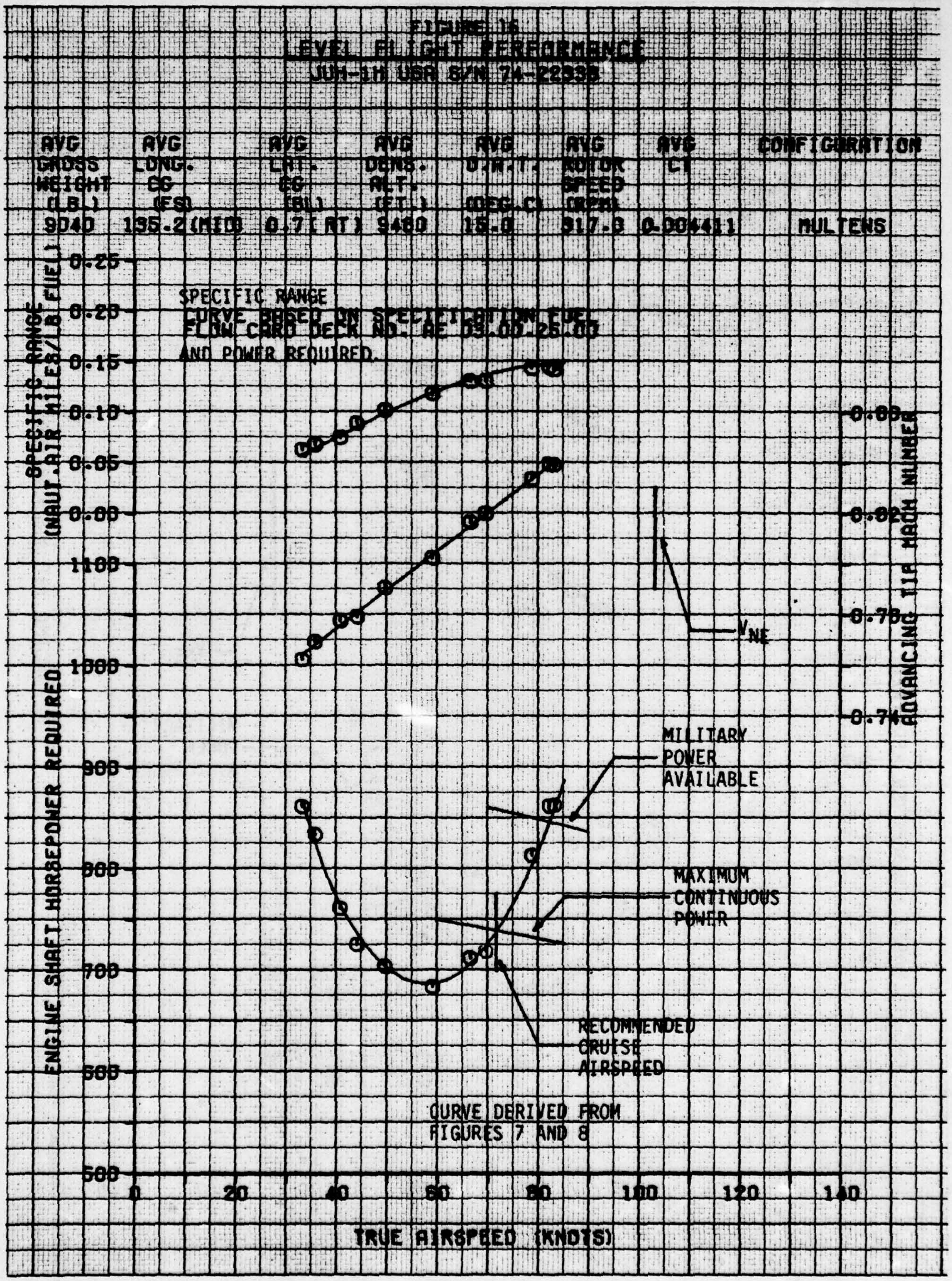


FIGURE 16
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338
AVG GROSS WEIGHT (LB.) 9040
AVG LONG. CG (FS) 135.2(MID)
AVG LAT. CG (BL) 0.7(RT)
AVG DENS. ALT. (FT.) 9480
AVG OAT (DEG.C) 15.0
AVG ROTOR SPEED (RPM) 317.0
AVG CT 0.004411
CONFIGURATION MULTENS
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
SPECIFIC RANGE
CURVE BASED ON SPECIFICATION FUEL
FLOW CARD DECK NO. AE 03.00-25.00
AND POWER REQUIRED.
ADVANCING TIP MACH NUMBER
V_{NE}
ENGINE SHAFT HORSEPOWER REQUIRED
MILITARY POWER AVAILABLE
MAXIMUM CONTINUOUS POWER
RECOMMENDED CRUISE AIRSPEED
CURVE DERIVED FROM FIGURES 7 AND 8
TRUE AIRSPEED (KNOTS)

FIGURE 17
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22338

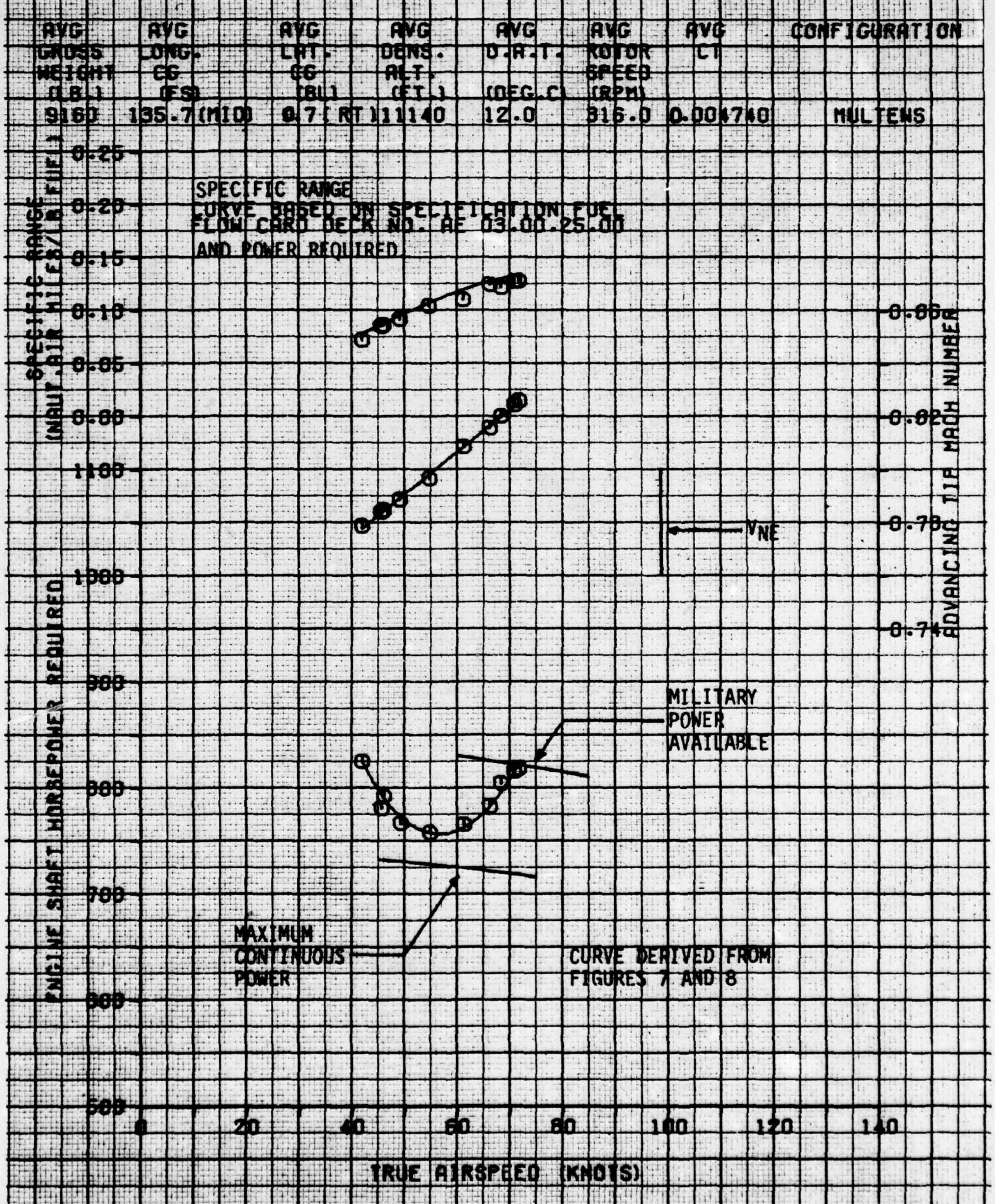
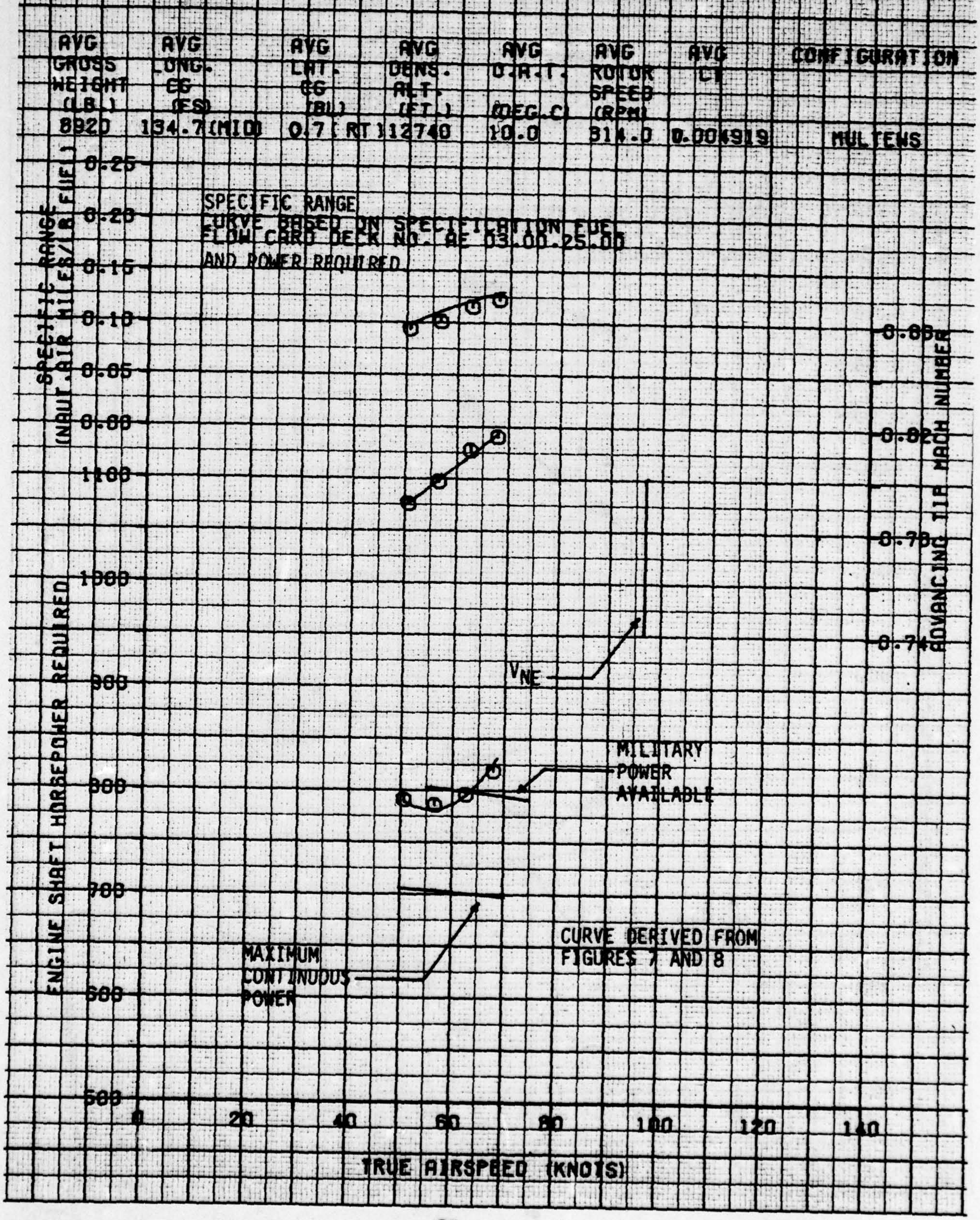


FIGURE 18
LEVEL FLIGHT PERFORMANCE
JUH-1H USA S/N 74-22538



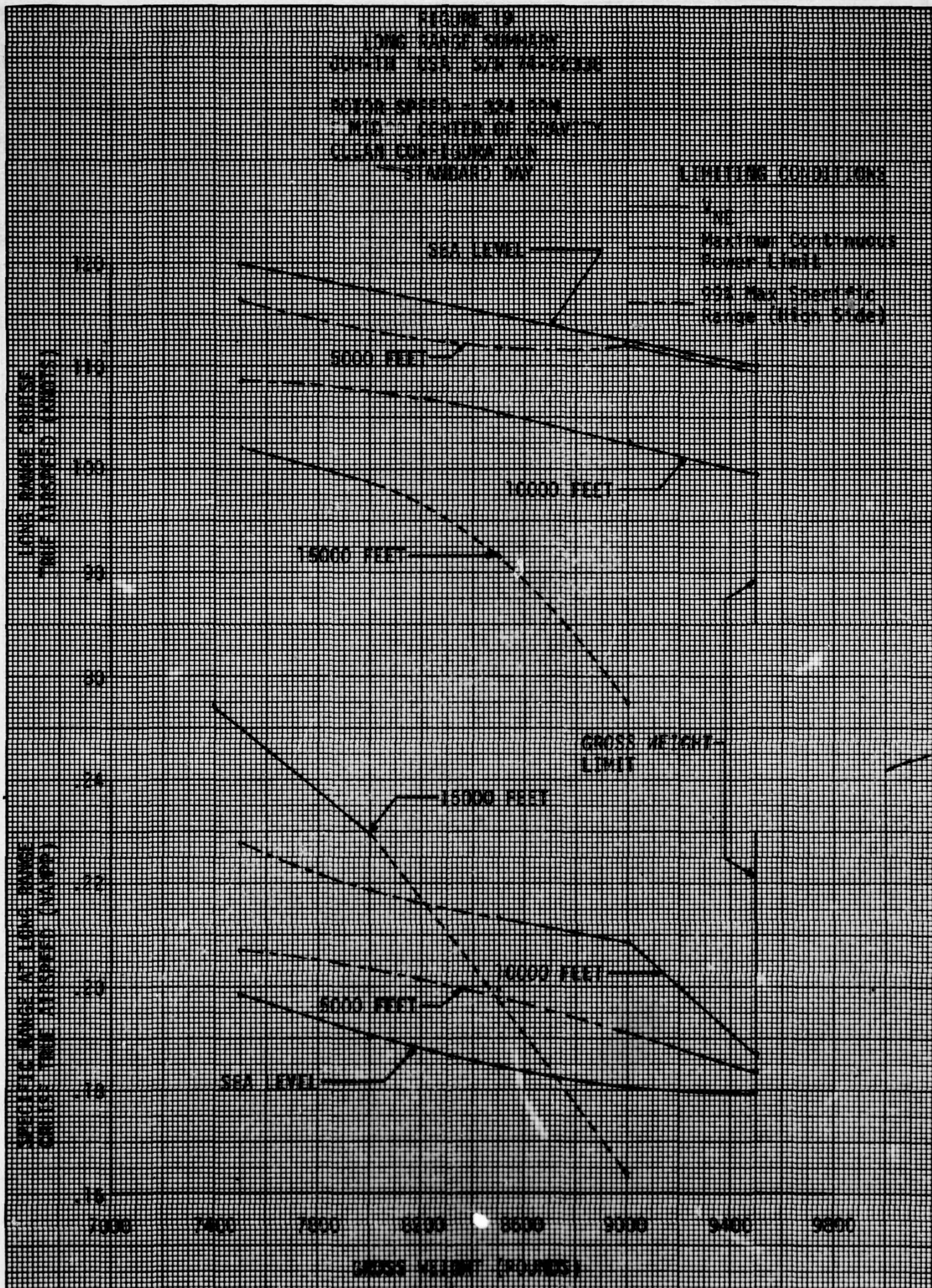


FIGURE 19
LONG RANGE SUMMARY
ROTOR SPEED – 324 RPM
MID CENTER OF GRAVITY
CLEAN CONFIGURATION
STANDARD DAY
LIMITING CONDITIONS
Maximum Continuous Power Limit
99% Max Specific Range (High Side)
SEA LEVEL
5000 FEET
10000 FEET
15000 FEET
GROSS WEIGHT LIMIT
LONG RANGE CRUISE TRUE AIRSPEED (KNOTS)
SPECIFIC RANGE AT LONG RANGE CRUISE TRUE AIRSPEED (NAMPP)
120
110
100
90
80
.24
.22
.20
.18
.16
7000
7400
7800
8200
8600
9000
9400
9800
GROSS WEIGHT (POUNDS)

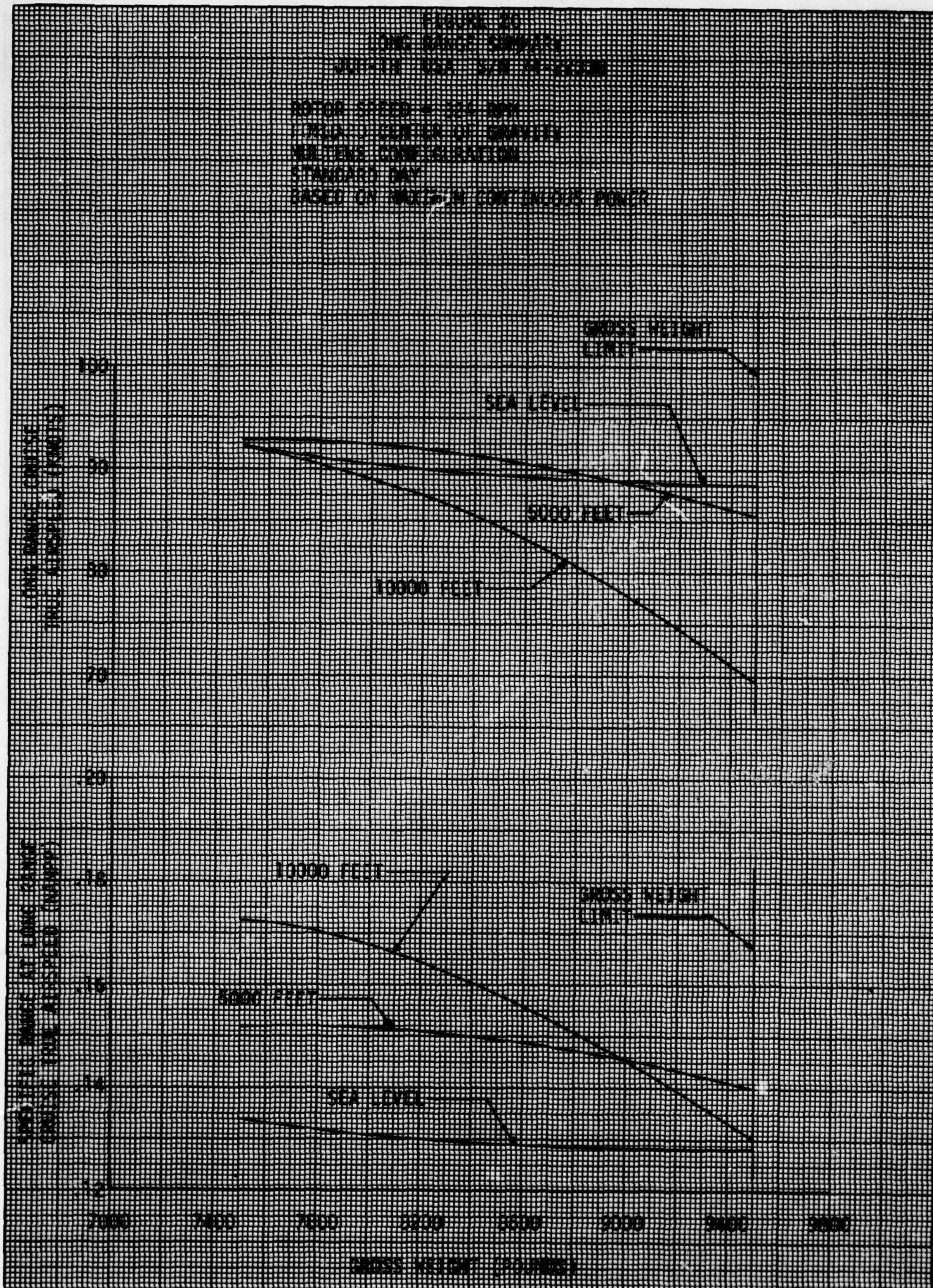


FIGURE 20
LONG RANGE SUMMARY
ROTOR SPEED = 324 RPM
STANDARD DAY
BASED ON MAXIMUM CONTINUOUS POWER
GROSS WEIGHT LIMIT
SEA LEVEL
5000 FEET
10000 FEET
100
90
80
70
.20
.18
.16
.14
.12
7000
7400
7800
8200
8600
9000
9400
9800
GROSS WEIGHT (POUNDS)

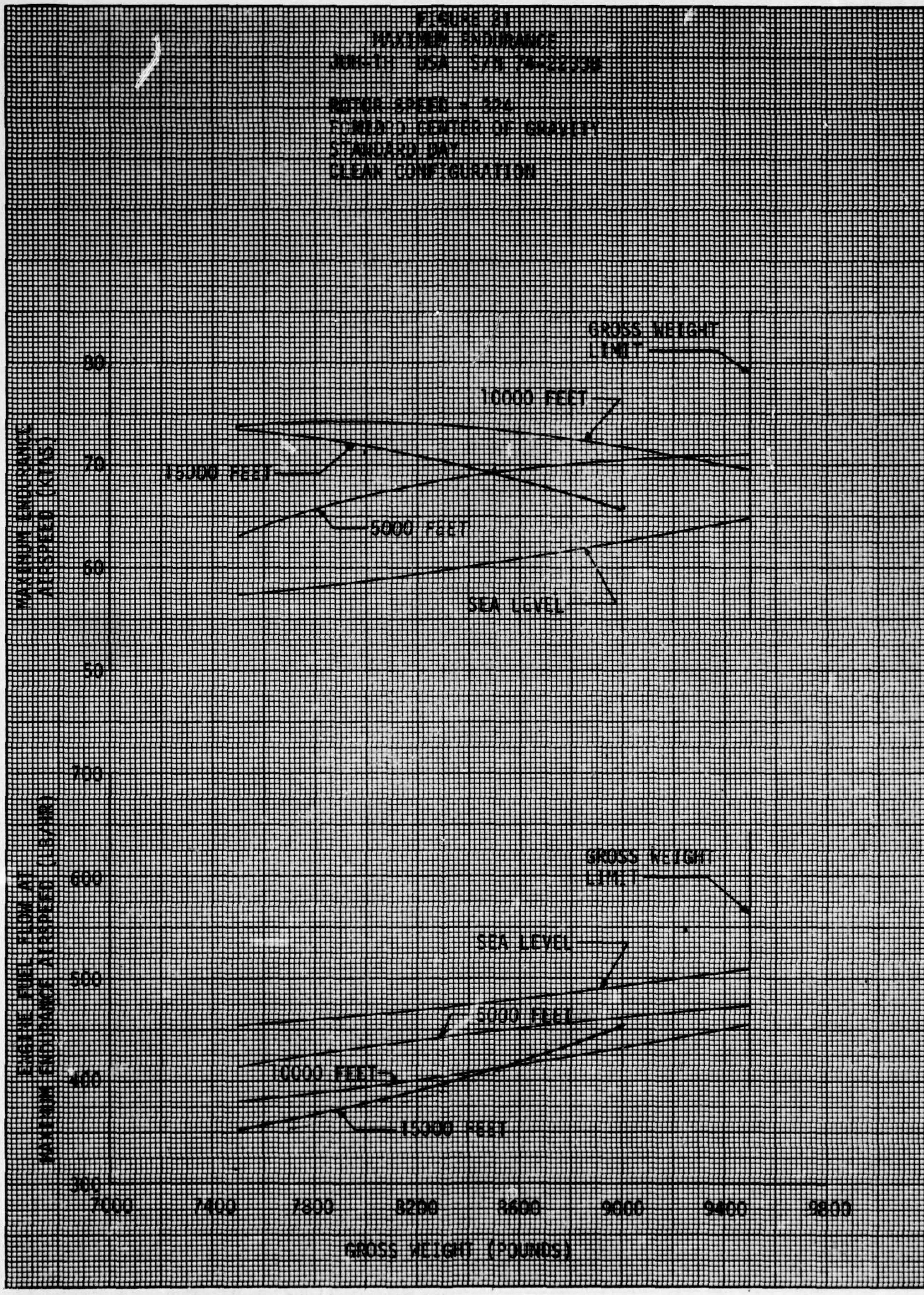
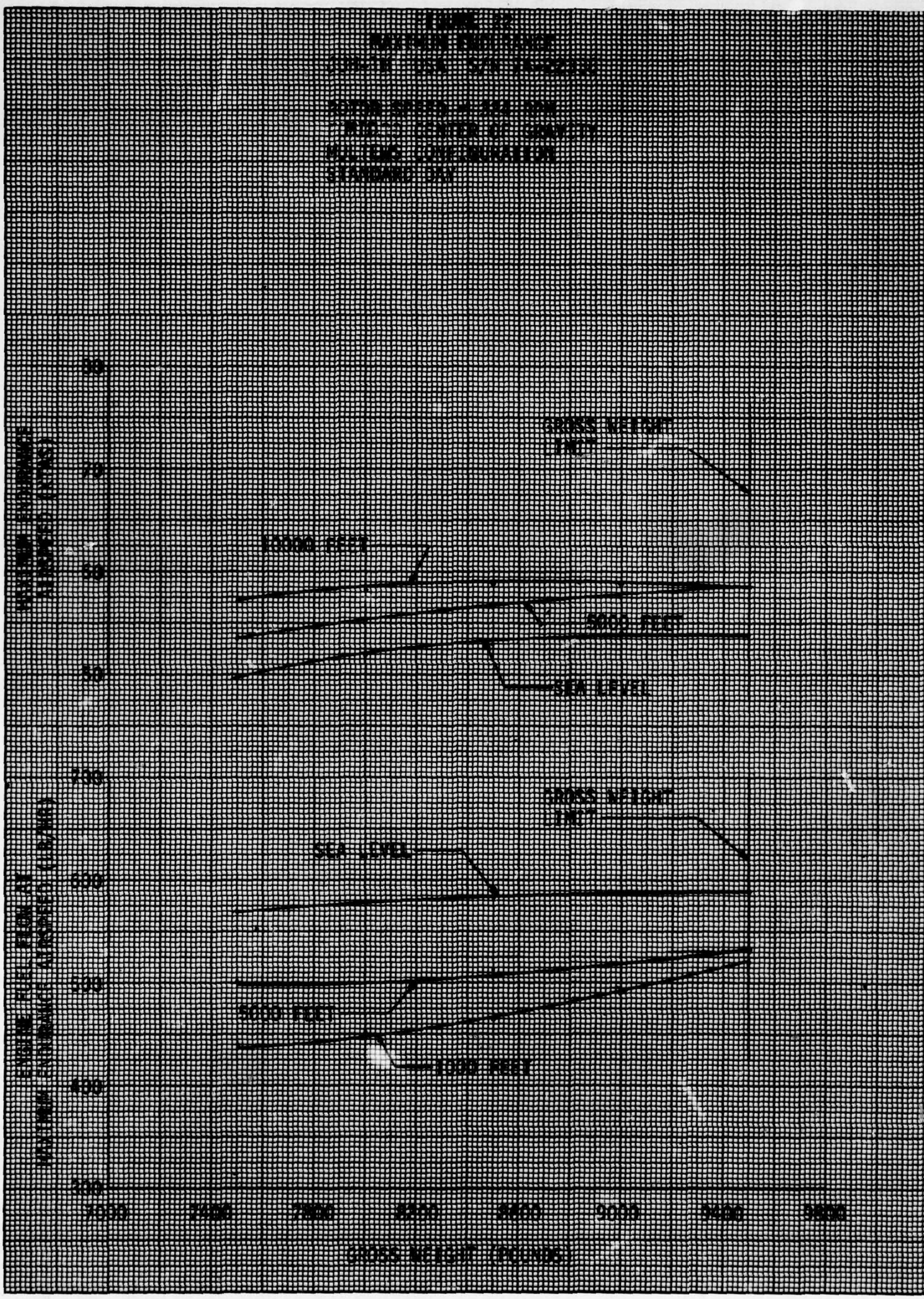


FIGURE 21
MAXIMUM ENDURANCE
STANDARD DAY
CLEAN CONFIGURATION
GROSS WEIGHT LIMIT
10000 FEET
15000 FEET
5000 FEET
SEA LEVEL
MAXIMUM ENDURANCE AIRSPEED (KTS)
80
70
60
50
700
600
500
400
300
GROSS WEIGHT LIMIT
SEA LEVEL
5000 FEET
10000 FEET
15000 FEET
7000
7400
7800
8200
8600
9000
9400
9800
GROSS WEIGHT (POUNDS)



MAXIMUM ENDURANCE
STANDARD DAY
GROSS WEIGHT LIMIT
10000 FEET
5000 FEET
SEA LEVEL
MAXIMUM ENDURANCE AIRSPEED (KTAS)
ENGINE FUEL FLOW AT MAXIMUM ENDURANCE AIRSPEED (LB/HR)
GROSS WEIGHT (POUNDS)
7000
7400
7800
8200
8600
9000
9400
9800

FIGURE 23
AUTOROTATION PERFORMANCE
JUH-1H USA S/N 74-22338
GROSS WEIGHT = 9200 LB
PRESSURE ALTITUDE = 5000 FEET
STANDARD DAY
ROTOR SPEED = 324 RPM

NOTE: 1. CURVES DERIVED FROM FIGS. 3 AND 4.

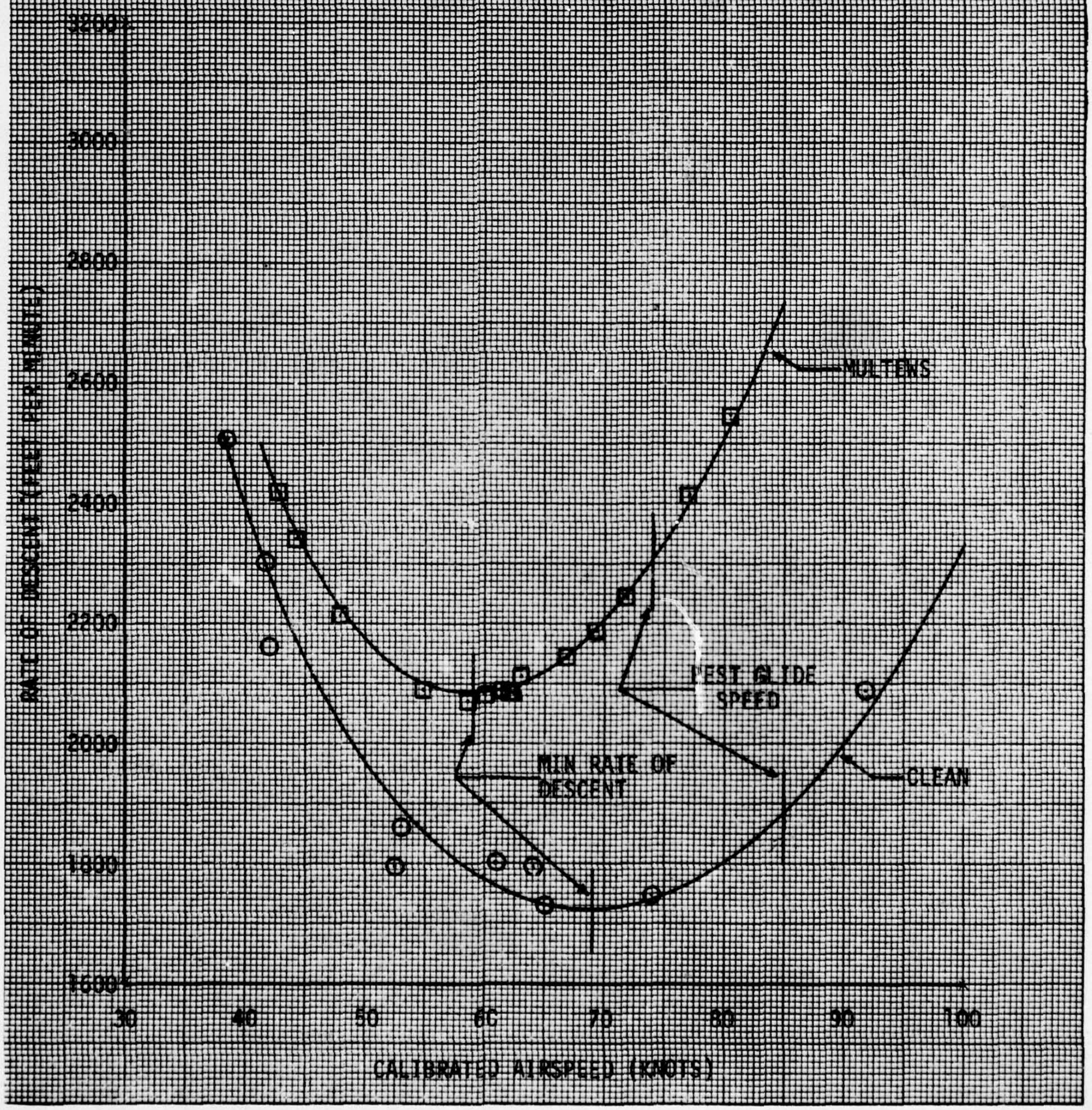


FIGURE 24
HEIGHT VELOCITY
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ENTRY ROTOR SPEED (RPM)	ENTRY CALIBRATED AIRSPEED (KTS)	CONFIG
8300	135.6 (MID)	0.2 (RT)	1820	7.5	321	55	MULTEMS

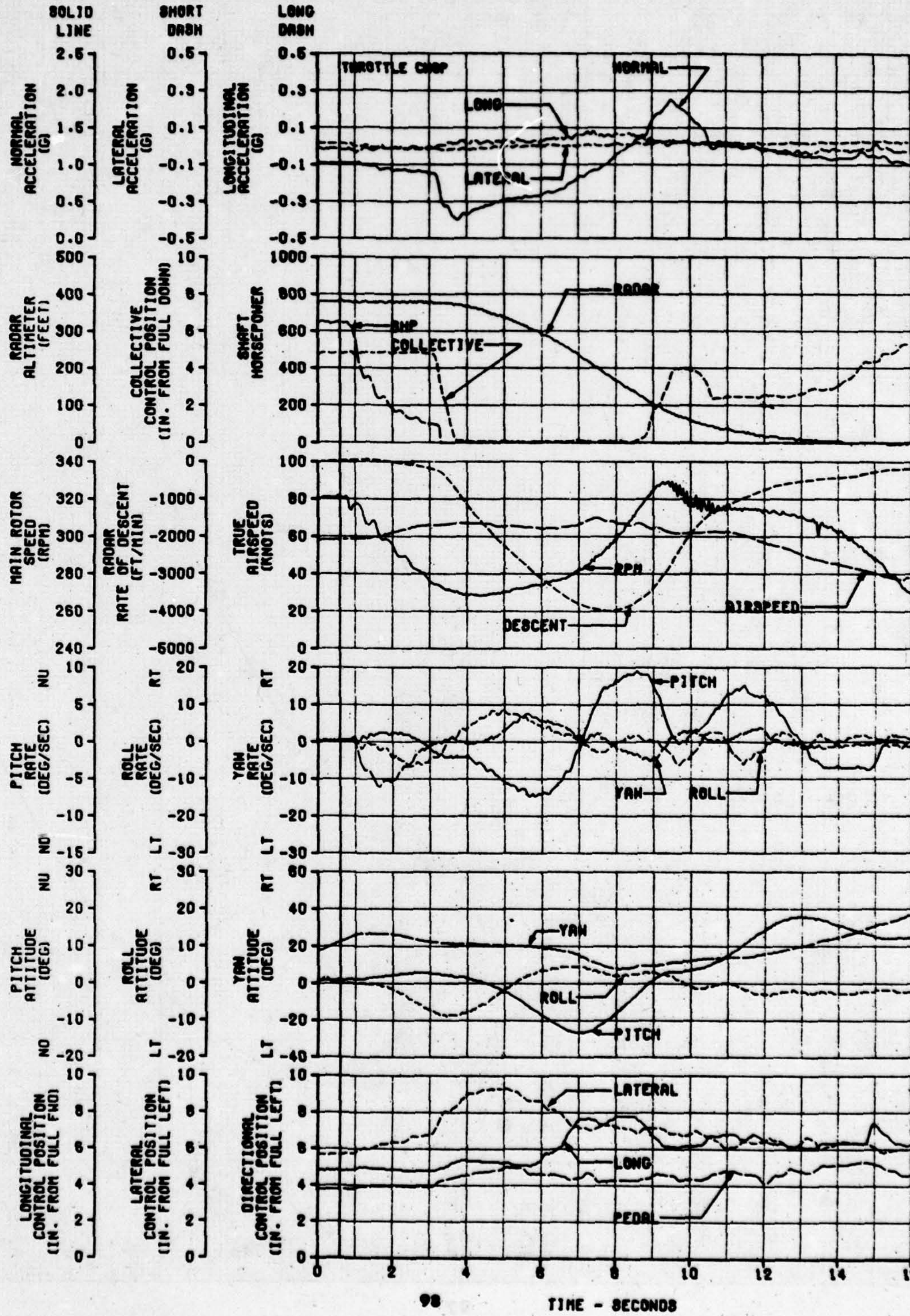


FIGURE 25

HEIGHT VELOCITY

JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ENTRY ROTOR SPEED (RPM)	ENTRY CALIBRATED AIRSPEED (KTS)	CONFIG
9280	135.1 (MID)	0.2 (RT)	1900	8.5	322	66	MULTENG

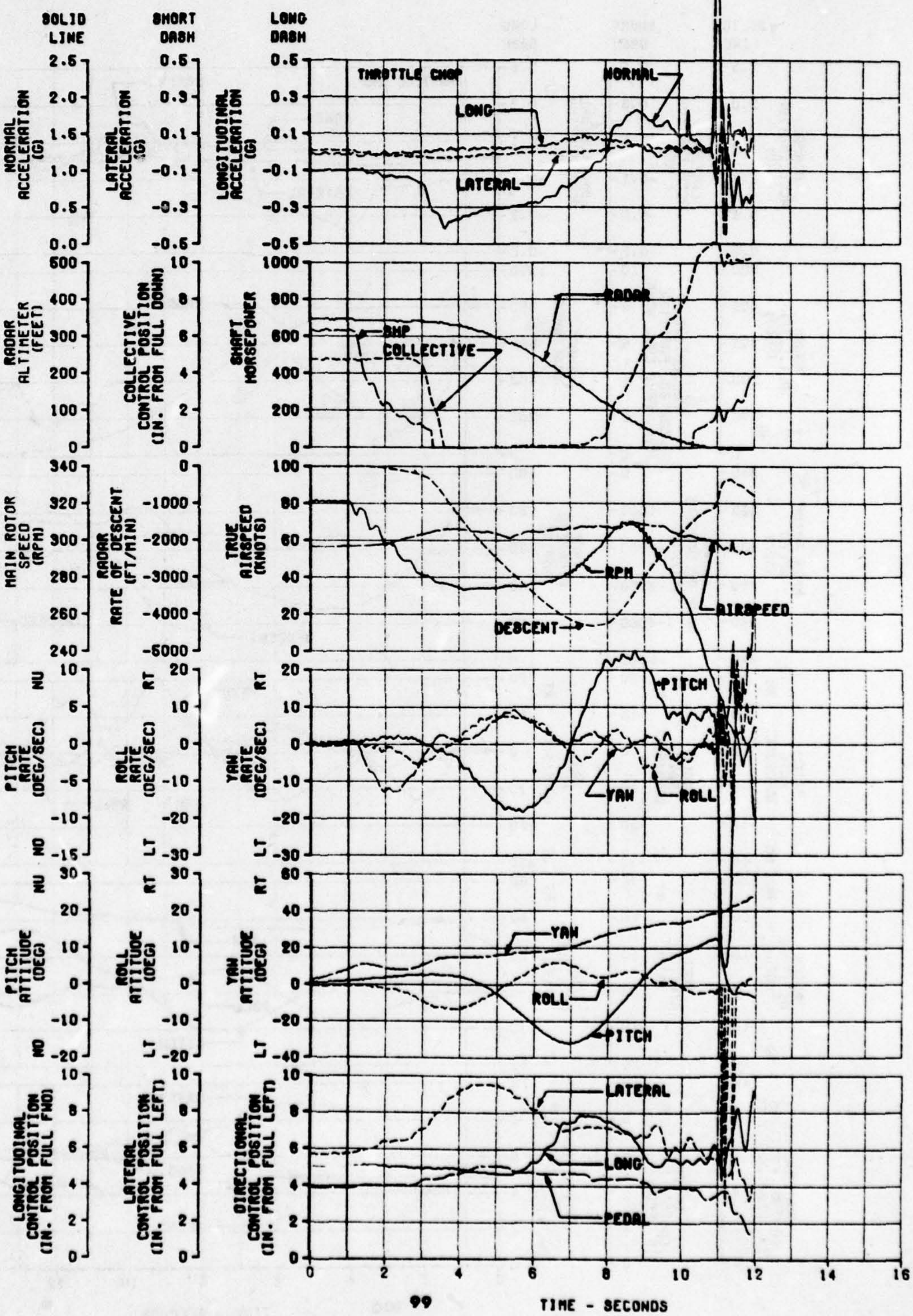


FIGURE 26
HEIGHT VELOCITY
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ENTRY ROTOR SPEED (RPM)	ENTRY CALIBRATED AIRSPEED (KTS)	CONFIG
9260	135.8 (MID)	0.2 (RT)	1920	8.5	321	55	MULTENS

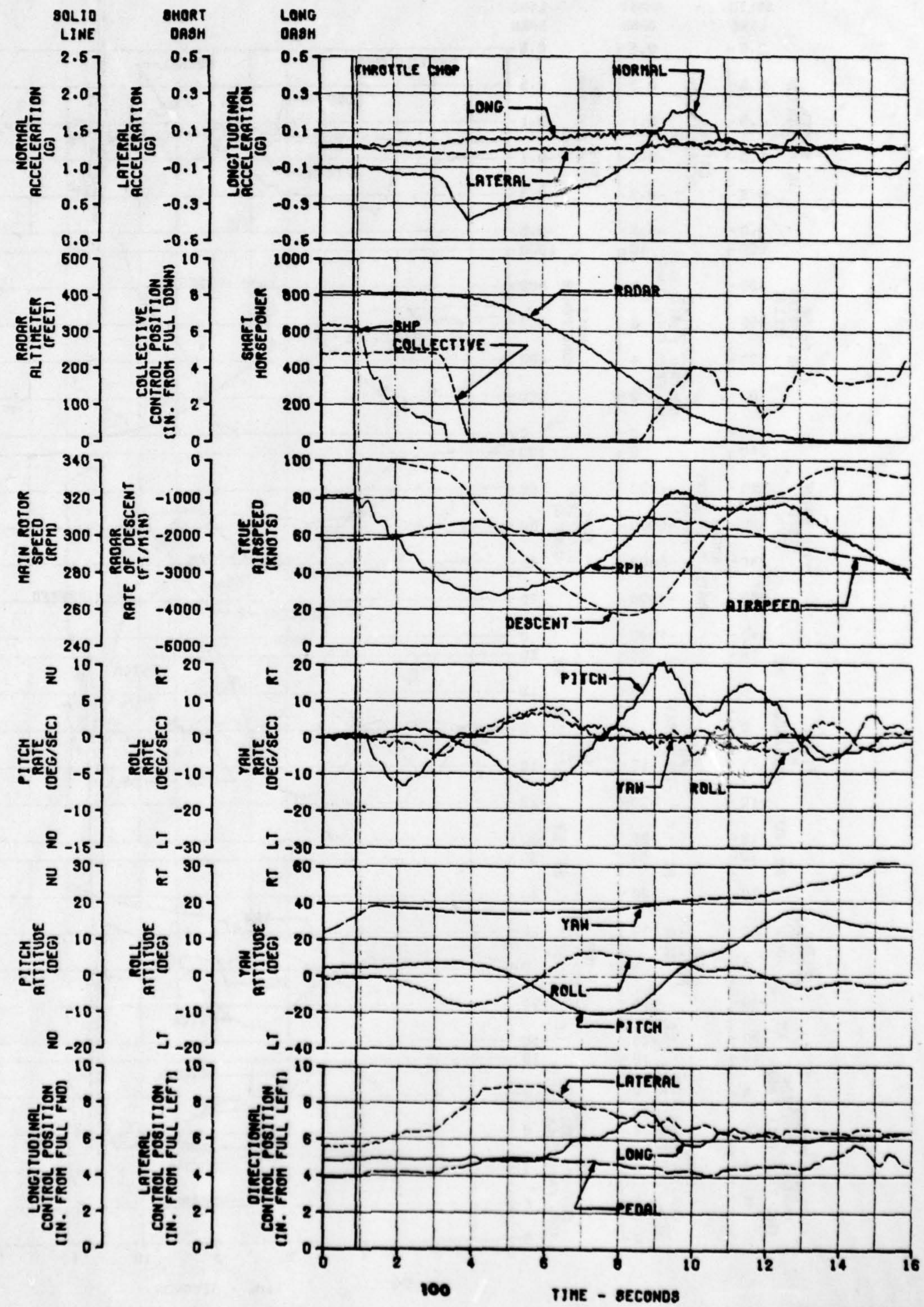


FIGURE 27
LIMITS OF CYCLIC CONTROL TRAVEL
JUH-1H USA S/N 74-22338

NOTES: 1. ROTORS STATIC.
2. CONTROL POSITION MEASURED AT CENTER OF GRIP.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
4. CYCLIC TRIM POSITIONS:
6.2 INCHES FROM FULL FORWARD.
6.3 INCHES FROM FULL LEFT.

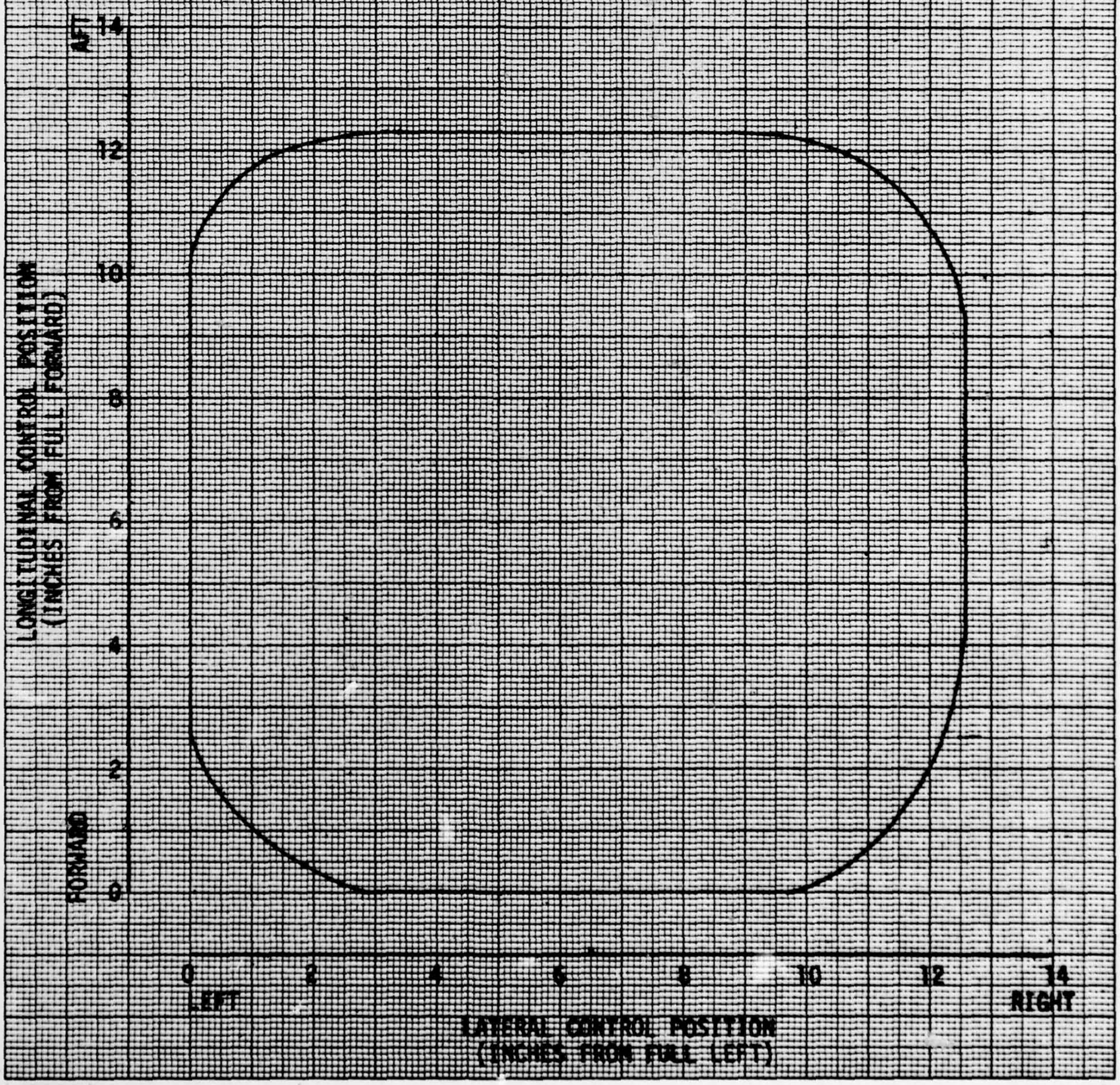


FIGURE 28
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
[illegible]

NOTES:
1. ROTORS STATIC.
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
4. TOTAL LONGITUDINAL CONTROL TRAVEL = 12.3 INCHES.
5. LATERAL CONTROL POSITION = 6.3 INCHES FROM FULL LEFT.
6. FORCE TRIM ON, CYCLIC FRICTION AT ZERO.

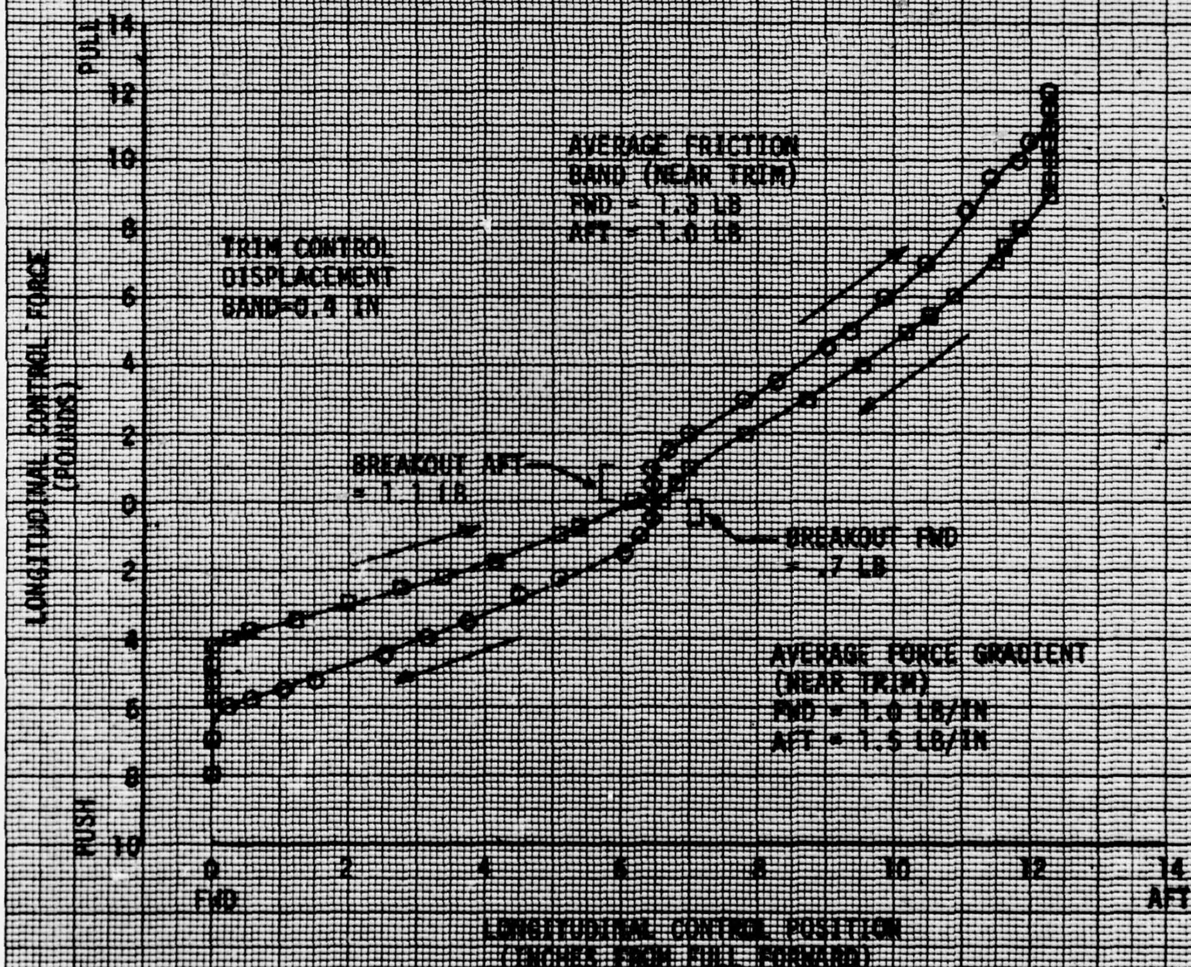


FIGURE 29
LATERAL CONTROL SYSTEM CHARACTERISTICS
AH-1S USA S/N 76-22338

NOTES: 1. ROTORS STATIC.
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNIT.
4. TOTAL LATERAL CONTROL TRAVEL = 12.6 INCHES.
5. LONGITUDINAL CONTROL POSITION = 6.4 INCHES FROM FULL FORWARD.
6. FORCE TRIM ON, CYCLIC FRICTION AT ZERO.

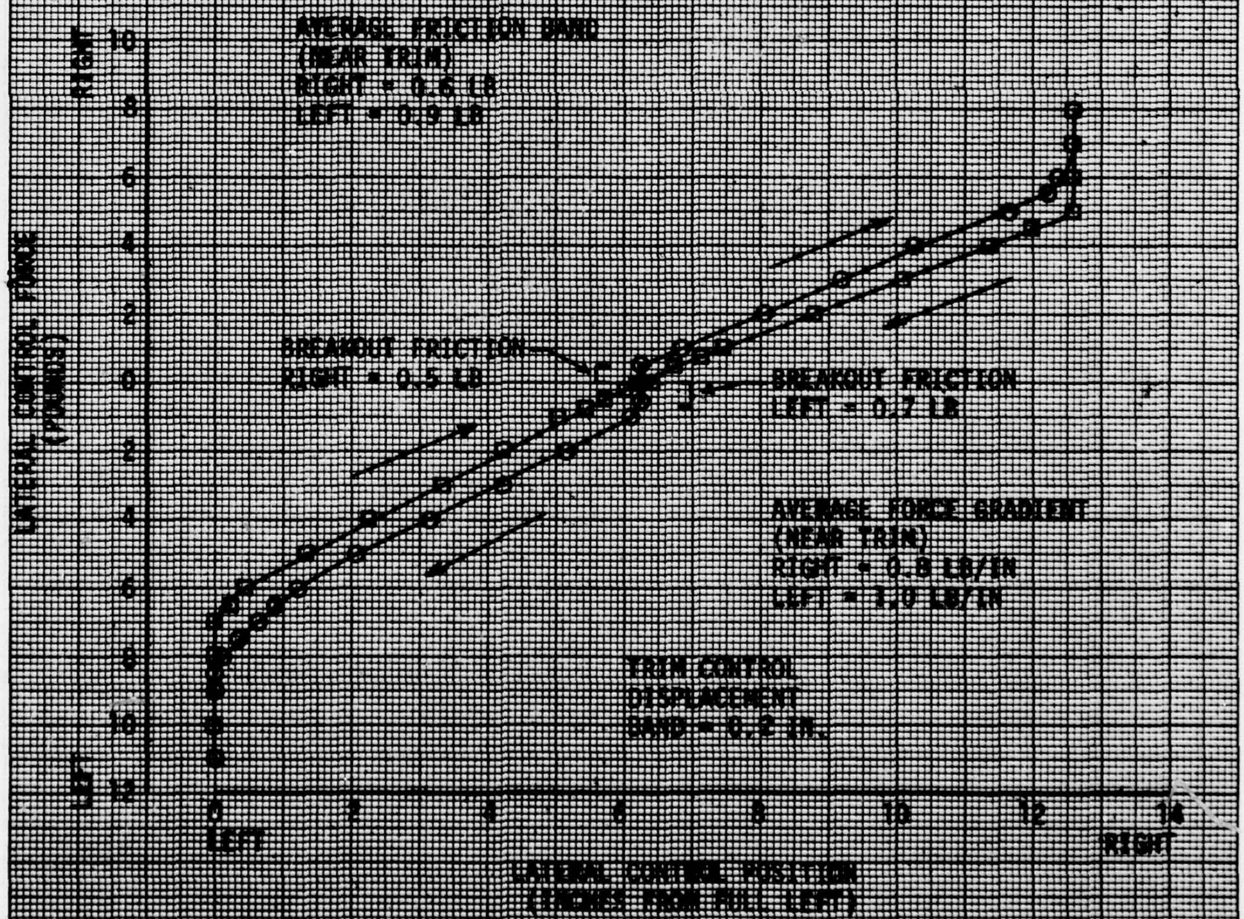
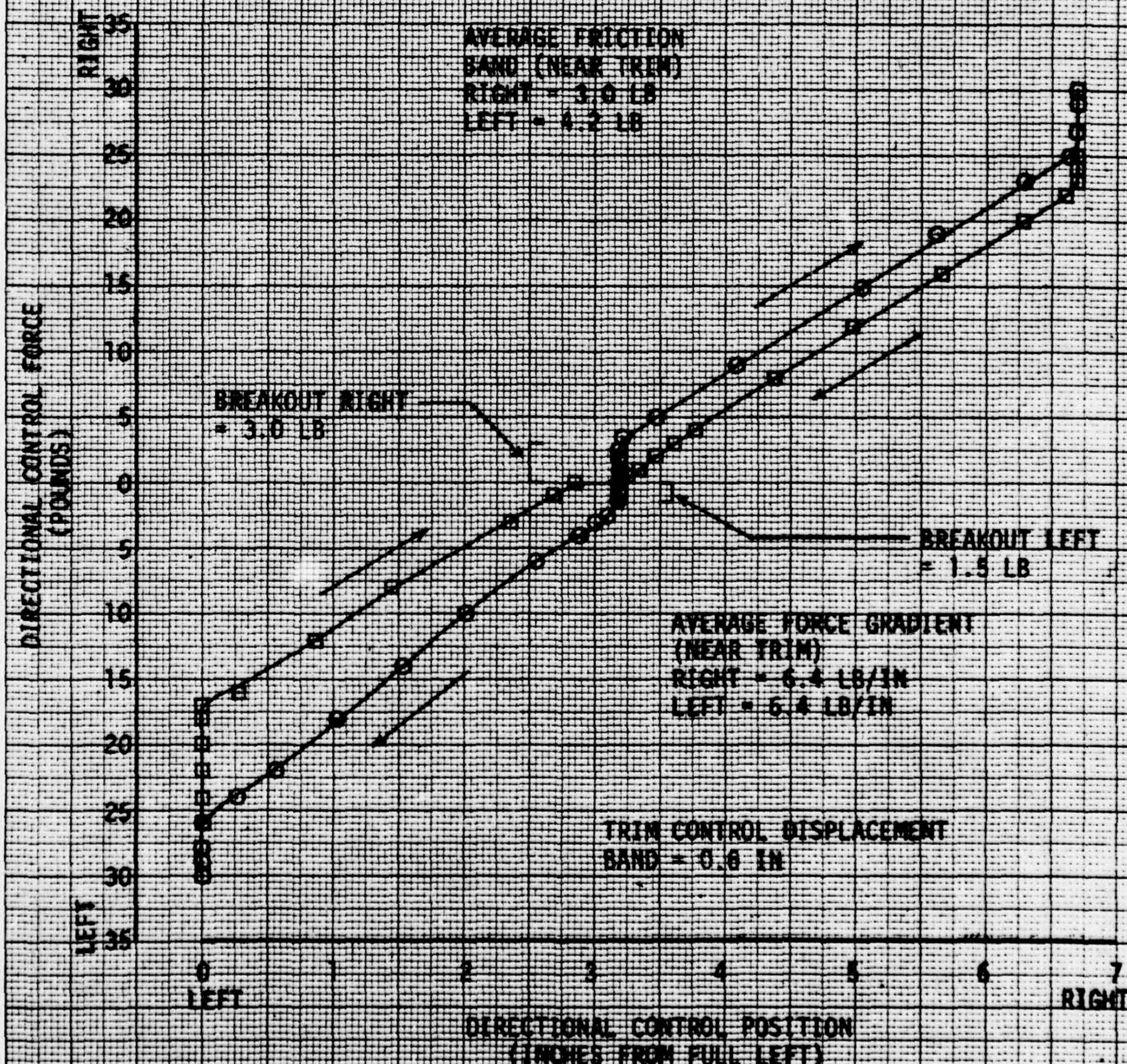


FIGURE 30
DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS
JUH-1H USA S/N 74-22330

NOTES: 1. ROTORS STATIC.
2. FORCES MEASURED AT THE PEDAL.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
4. TOTAL DIRECTIONAL CONTROL TRAVEL = 6.7 INCHES.
5. FORCE TRIM ON.



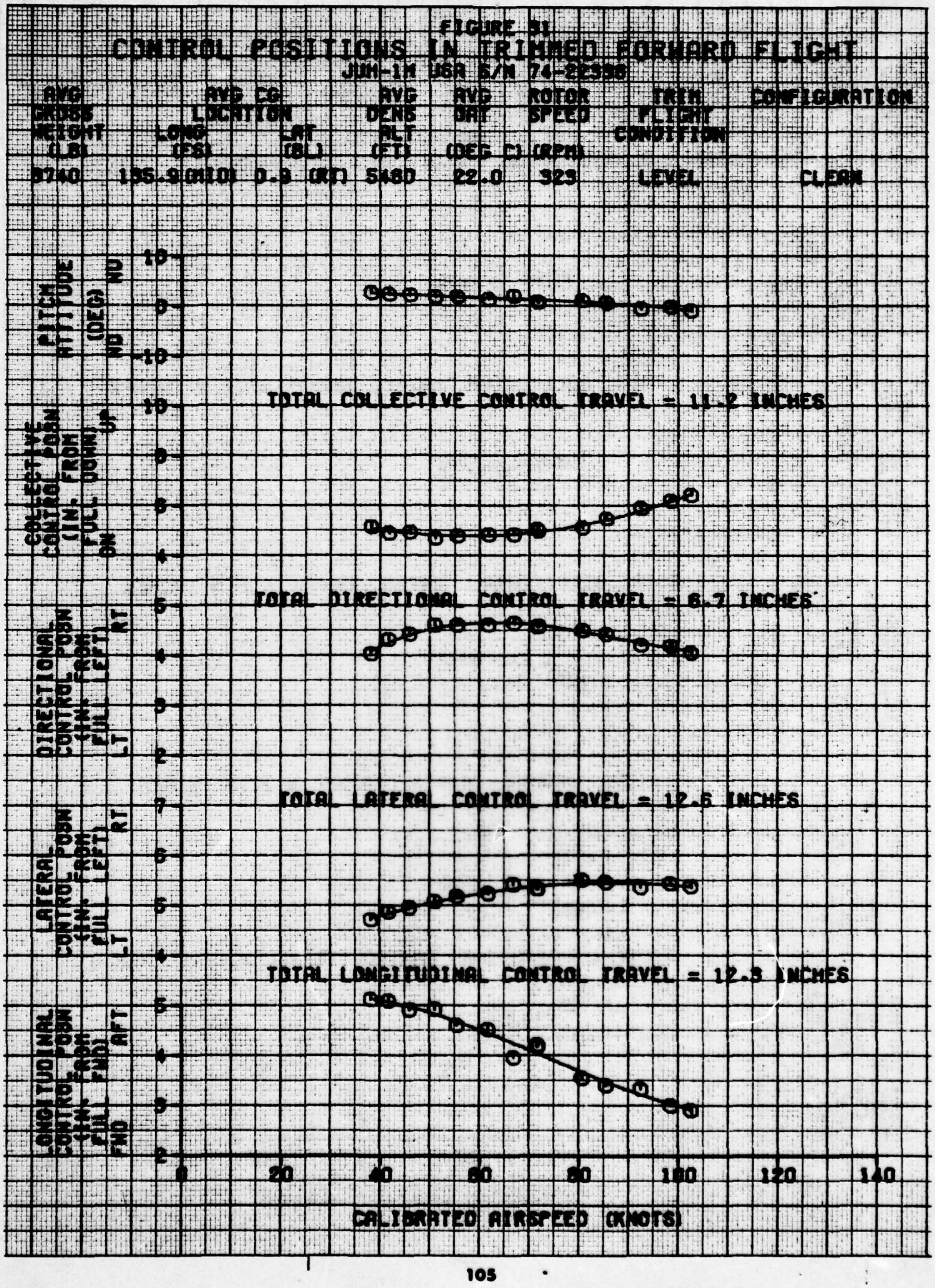


FIGURE 51
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
JUH-1H USA S/N 74-22336
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (DEG C)
ROTOR SPEED (RPM)
TRIM FLIGHT CONDITION
CONFIGURATION
8740
135.9(MID)
0.9 (RT)
5480
22.0
323
LEVEL
CLEAN
PITCH ATTITUDE (DEG)
NU
ND
10
0
-10
TOTAL COLLECTIVE CONTROL TRAVEL = 11.2 INCHES
COLLECTIVE CONTROL POSN (IN. FROM FULL DOWN)
UP
DN
10
8
6
4
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.7 INCHES
DIRECTIONAL CONTROL POSN (IN. FROM FULL LEFT)
RT
LT
5
4
3
2
TOTAL LATERAL CONTROL TRAVEL = 12.6 INCHES
LATERAL CONTROL POSN (IN. FROM FULL LEFT)
RT
LT
7
6
5
4
TOTAL LONGITUDINAL CONTROL TRAVEL = 12.3 INCHES
LONGITUDINAL CONTROL POSN (IN. FROM FULL FWD)
AFT
FWD
5
4
3
2
0
20
40
60
80
100
120
140
CALIBRATED AIRSPEED (KNOTS)

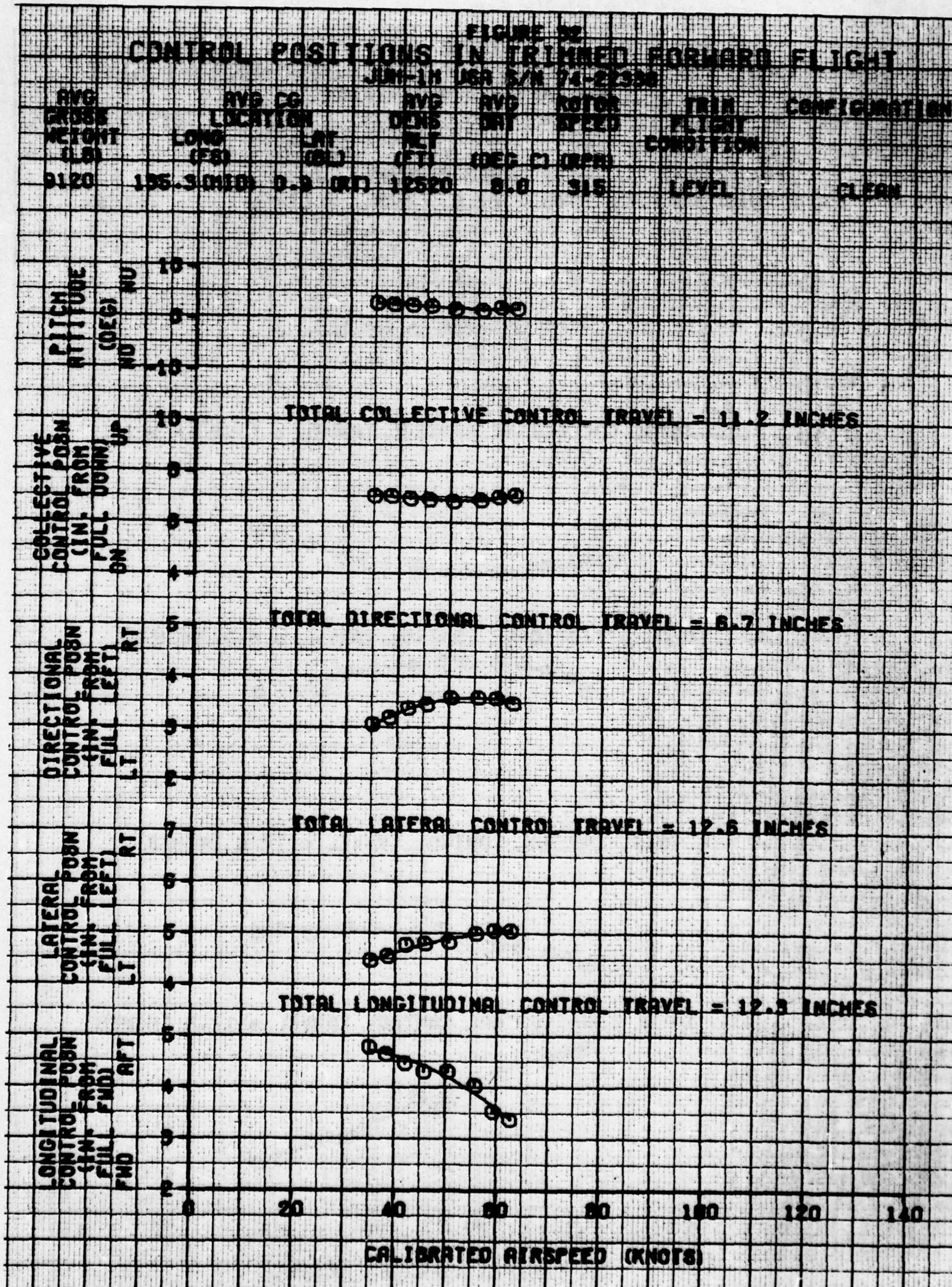


FIGURE 32
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
JUH-1H USA S/N 74-22330
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (DEG C)
ROTOR SPEED (RPM)
TRIM FLIGHT CONDITION
CONFIGURATION
9120
155.3 (MID)
0.3 (RT)
12520
8.0
315
LEVEL
CLEAN
PITCH ATTITUDE (DEG)
ND
NU
TOTAL COLLECTIVE CONTROL TRAVEL = 11.2 INCHES
COLLECTIVE CONTROL POSN (IN. FROM FULL DOWN)
DN
UP
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.7 INCHES
DIRECTIONAL CONTROL POSN (IN. FROM FULL LEFT)
LT
RT
TOTAL LATERAL CONTROL TRAVEL = 12.6 INCHES
LATERAL CONTROL POSN (IN. FROM FULL LEFT)
LT
RT
TOTAL LONGITUDINAL CONTROL TRAVEL = 12.3 INCHES
LONGITUDINAL CONTROL POSN (IN. FROM FULL FWD)
FWD
AFT
0
20
40
60
80
100
120
140
CALIBRATED AIRSPEED (KNOTS)

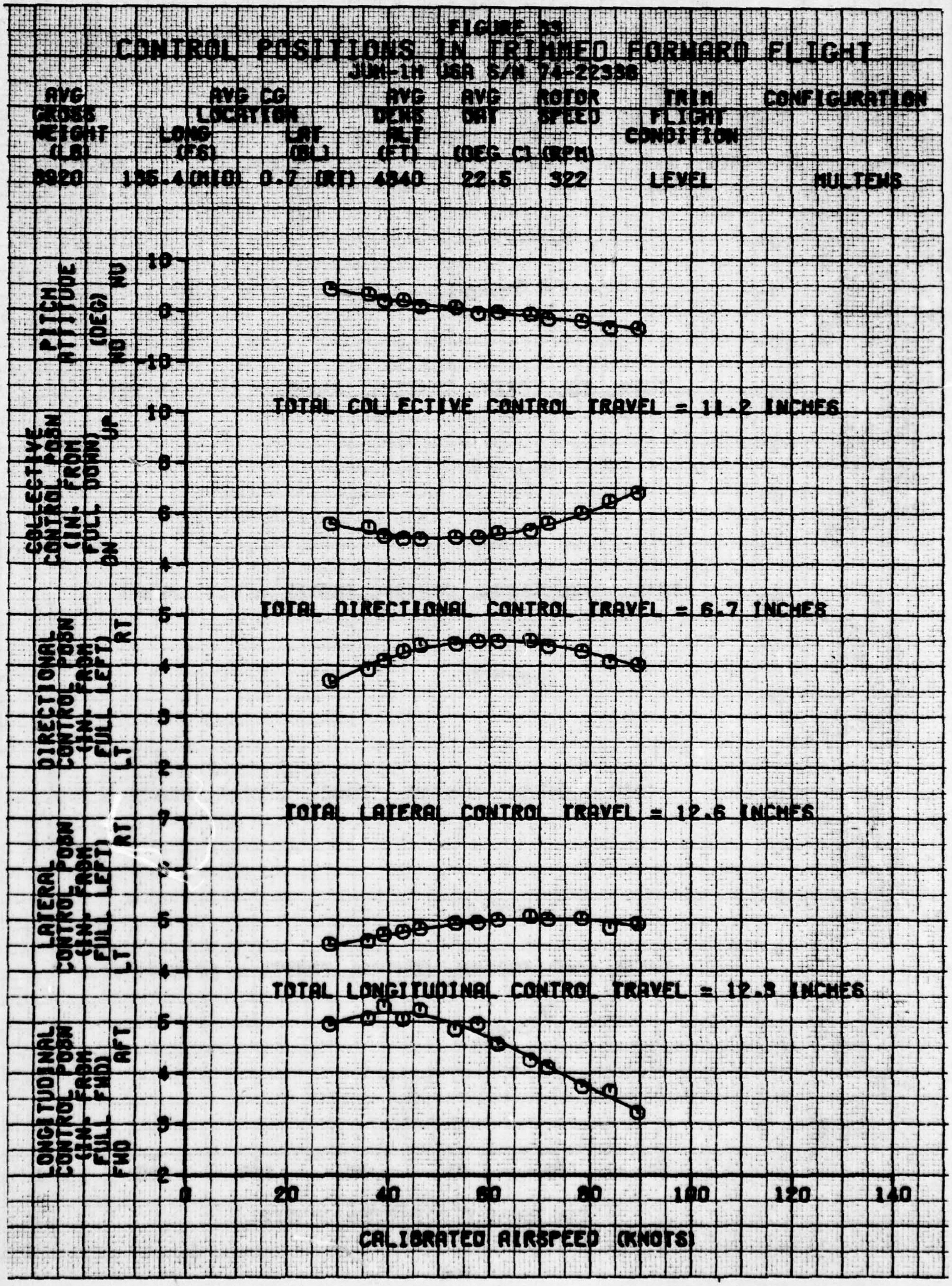


FIGURE 33
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
JUH-1H USA S/N 74-22338
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (DEG C)
ROTOR SPEED (RPM)
TRIM FLIGHT CONDITION
CONFIGURATION
8920
135.4 (MID)
0.7 (RT)
4840
22.5
322
LEVEL
MULTEWS
PITCH ATTITUDE (DEG)
ND
NU
COLLECTIVE CONTROL POSN (IN. FROM FULL DOWN)
DN
UP
TOTAL COLLECTIVE CONTROL TRAVEL = 11.2 INCHES
DIRECTIONAL CONTROL POSN (IN. FROM FULL LEFT)
LT
RT
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.7 INCHES
LATERAL CONTROL POSN (IN. FROM FULL LEFT)
LT
RT
TOTAL LATERAL CONTROL TRAVEL = 12.6 INCHES
LONGITUDINAL CONTROL POSN (IN. FROM FULL FWD)
FWD
AFT
TOTAL LONGITUDINAL CONTROL TRAVEL = 12.3 INCHES
10
0
-10
10
8
6
4
5
4
3
2
7
6
5
4
6
5
4
3
2
0
20
40
60
80
100
120
140
CALIBRATED AIRSPEED (KNOTS)

FIGURE 34

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

JUH-1H USA S/N 74-22356

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
3920	135.7 (MID)	0.7 (RT)	12740	10.0		LEVEL	MULTENS

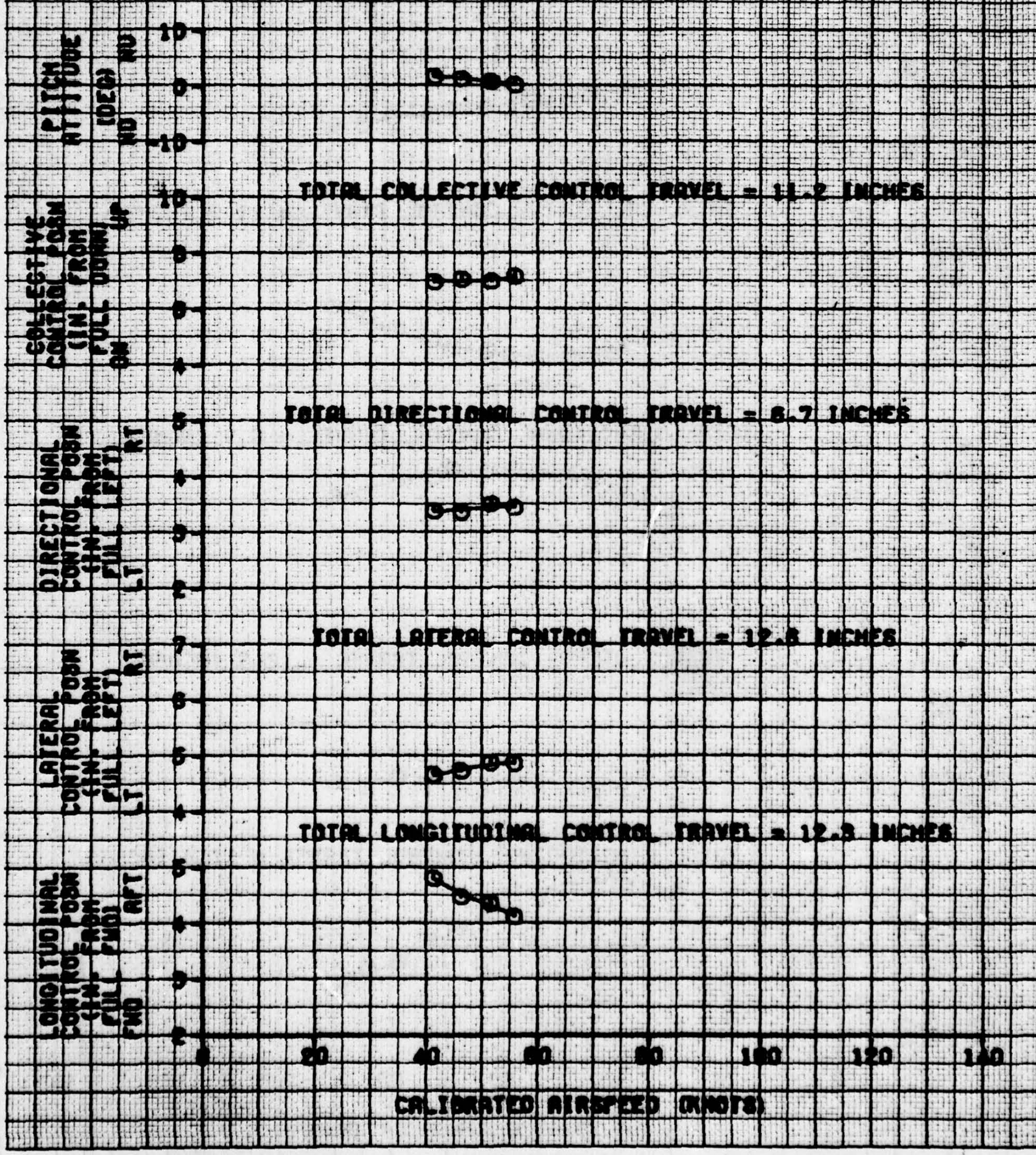
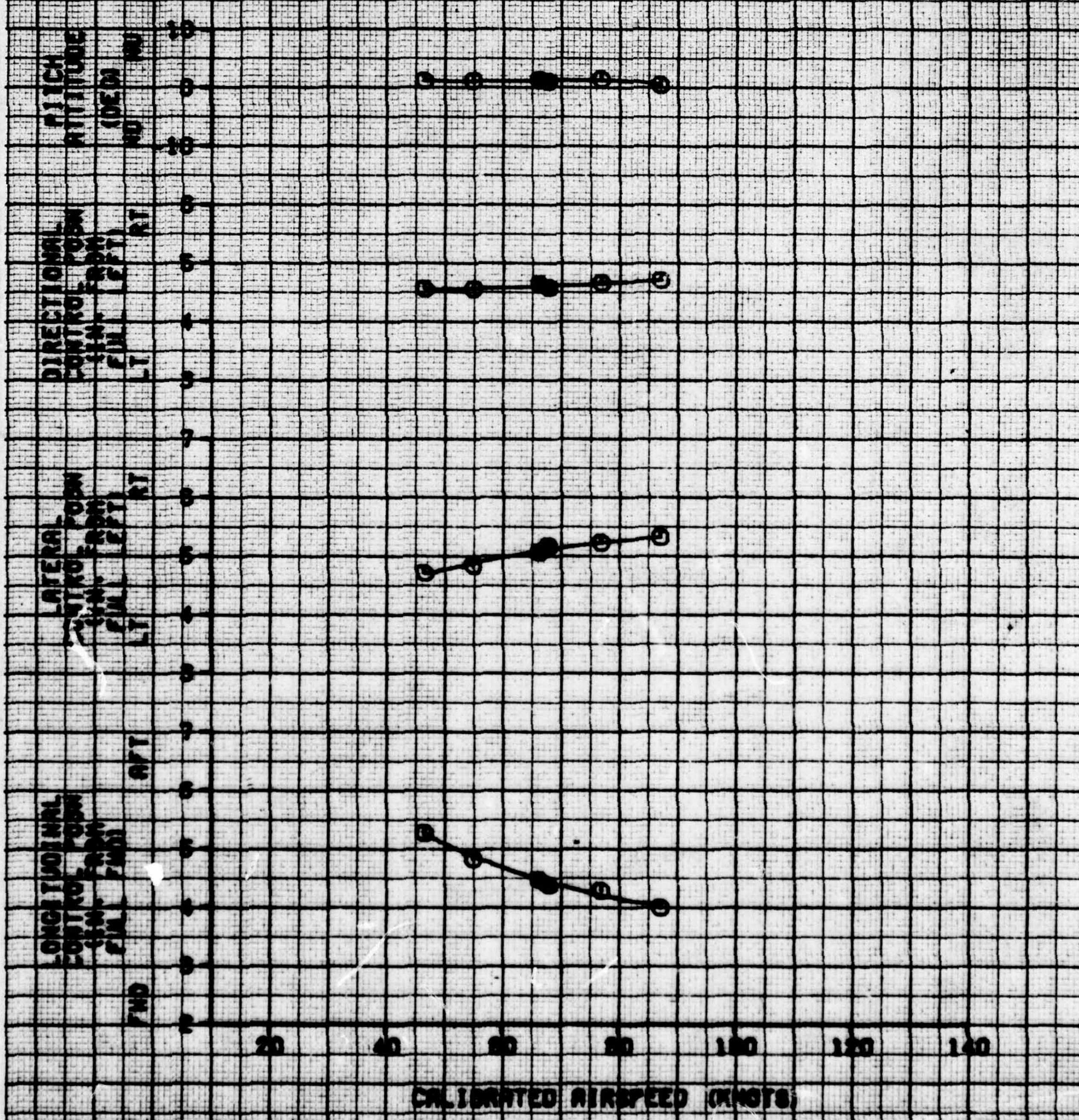


FIGURE 56
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
JUH-1H USA S/N 74-22356

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
[illegible]	134.9(MID)	0.9(RT)	4800	21.5	321	LEVEL	CLEAN

NOTE: SHADED SYMBOL DENOTES TRIM.



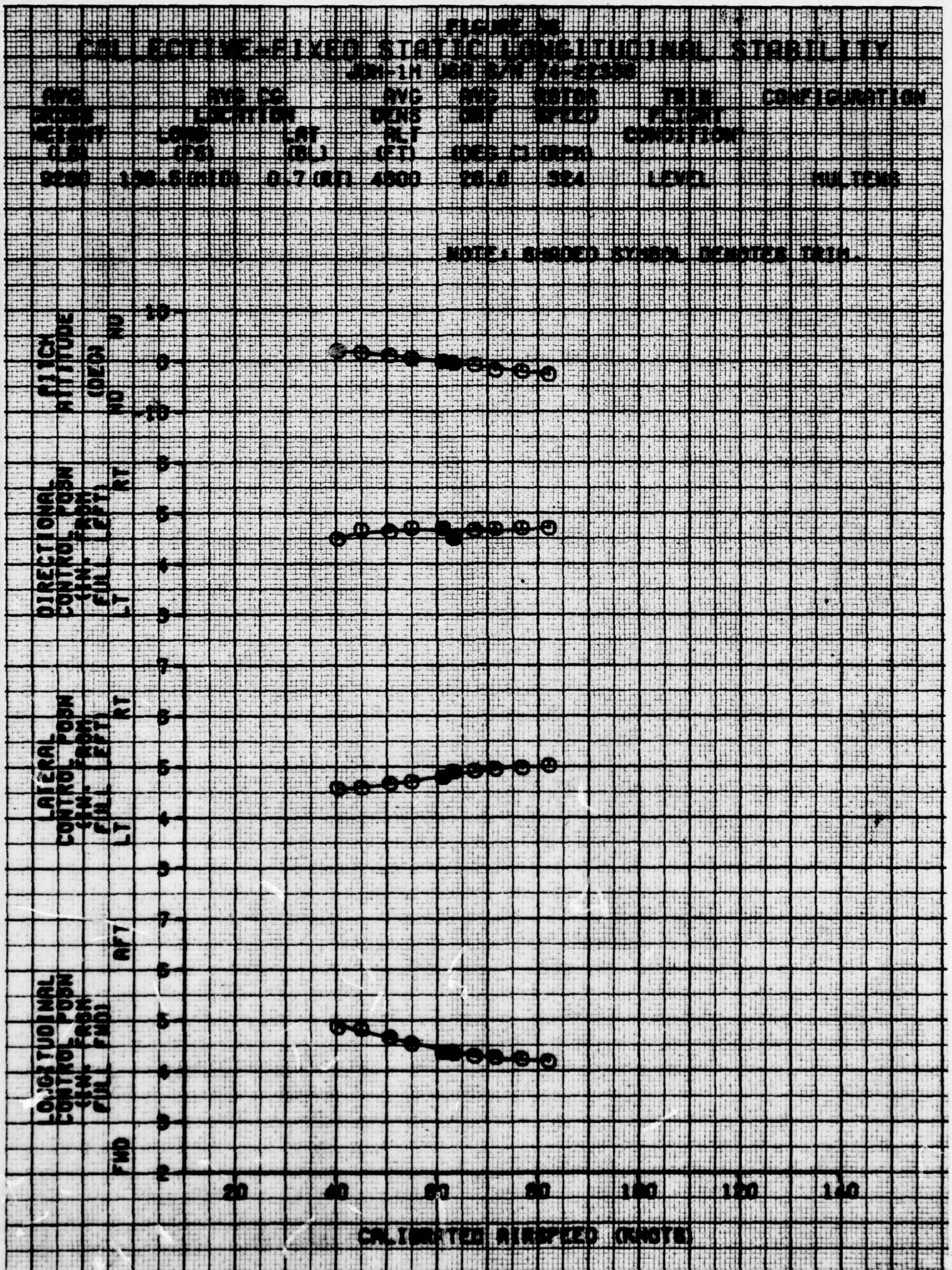


FIGURE
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
JUH-1H USA S/N 74-22330
AVG GROSS WEIGHT (LB) 9200
AVG CG LOCATION LONG (FS) 136.6(MID) LAT (BL) 0.7(RT)
AVG DENS ALT (FT) 4900
AVG OAT (DEG C) 26.0
ROTOR SPEED (RPM) 324
TRIM FLIGHT CONDITION LEVEL
CONFIGURATION MULTEMS
NOTE: SHADED SYMBOL DENOTES TRIM.
PITCH ATTITUDE (DEG) ND NU
DIRECTIONAL CONTROL POSN (IN. FROM FULL LEFT) LT RT
LATERAL CONTROL POSN (IN. FROM FULL LEFT) LT RT
LONGITUDINAL CONTROL POSN (IN. FROM FULL FWD) FWD AFT
CALIBRATED AIRSPEED (KNOTS)

FIGURE 37

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-22330

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
9040	135.7(MID)	0.7(RT)	5380	25.5	323	LEVEL	MULTEWS

NOTE: SHADED SYMBOL DENOTES TRIM.

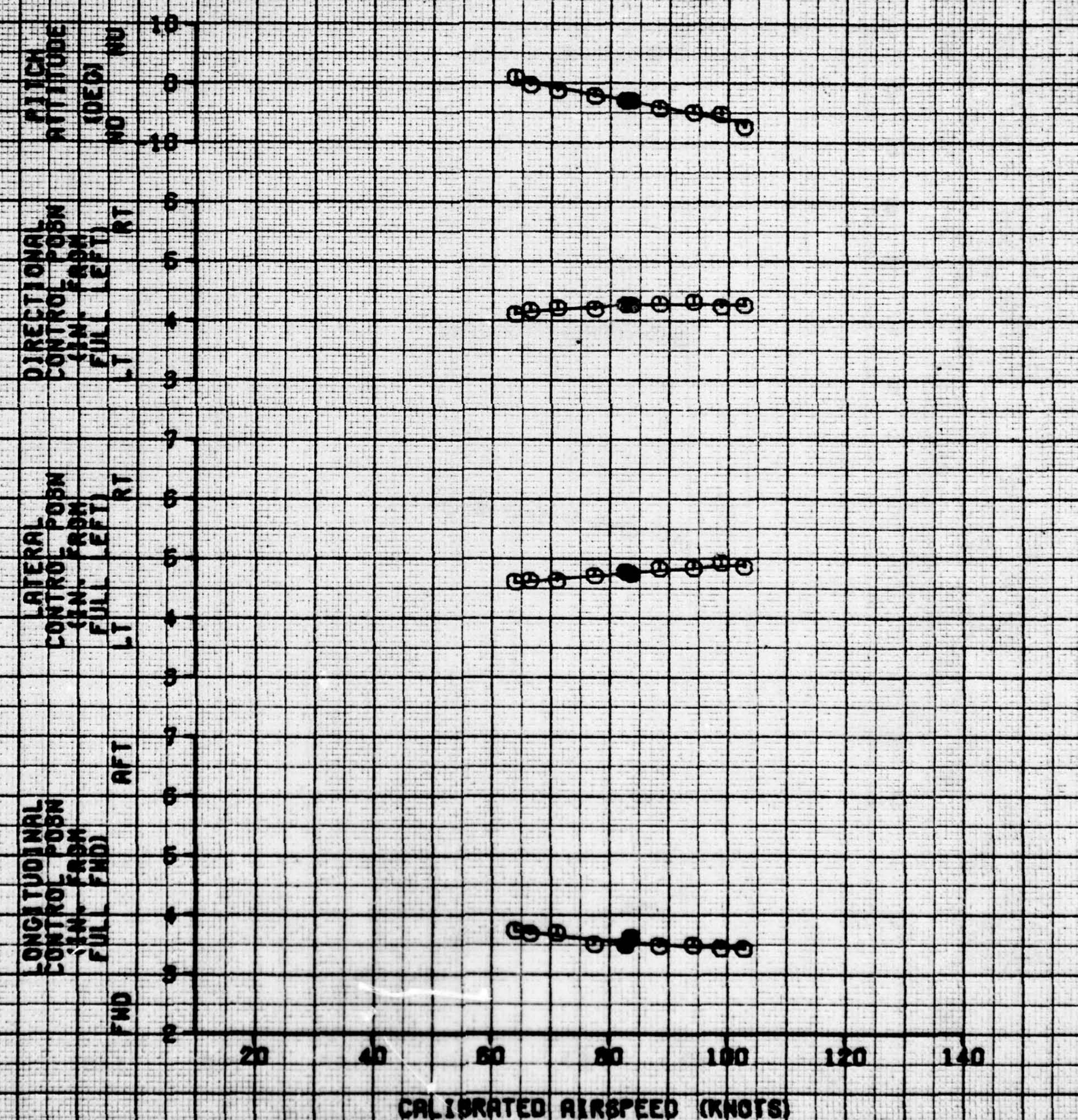


FIGURE 38
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
8400	140.8(AFT)	0.4(RT)	5160	14.5	324	LEVEL	CLEAN

NOTE: SHADED SYMBOL DENOTES TRIM.

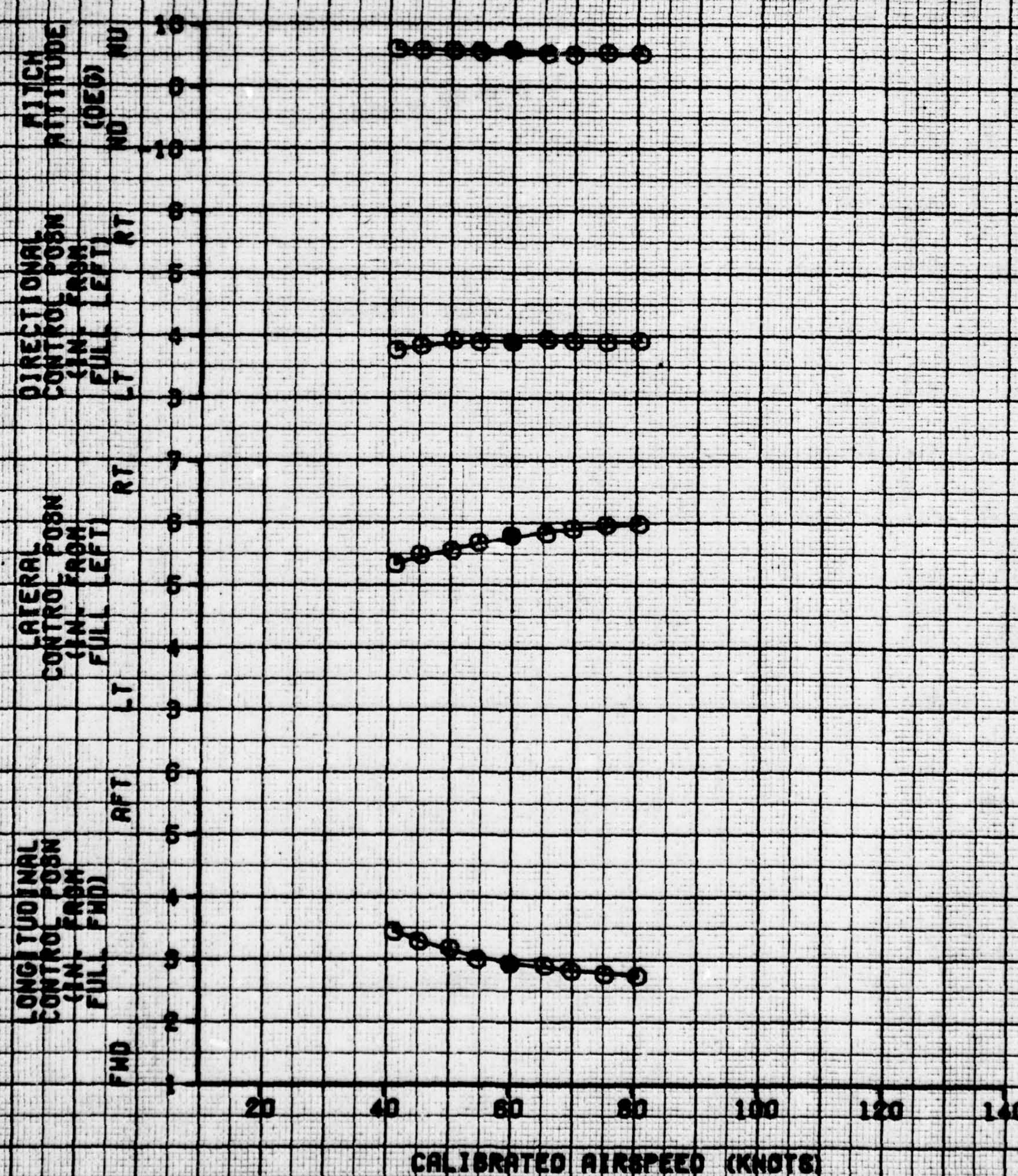


FIGURE 38

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-22398

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
9920	140.1 (AFT)	0.2 (RT)	4080	8.5	323	LEVEL	MULTENS

NOTE: SHADED SYMBOL DENOTES TRIM.

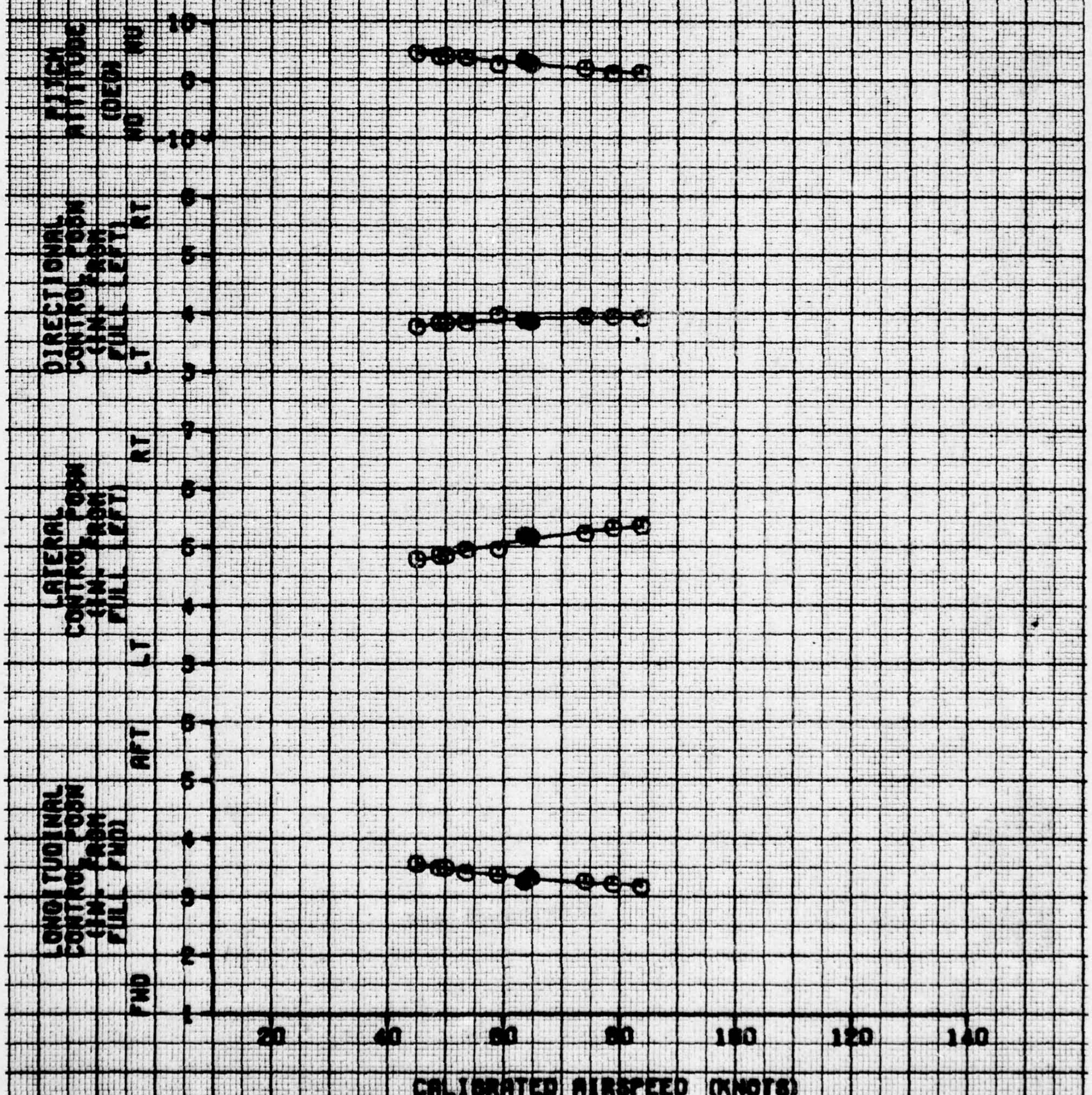


FIGURE 10
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
JUH-1H USA S/N 74-22330

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
9300	140.3 (AFT)	0.4 (RT)	5300	14.5	323	LEVEL	CLEAN

NOTE: SHADED SYMBOL DENOTES TRIM.

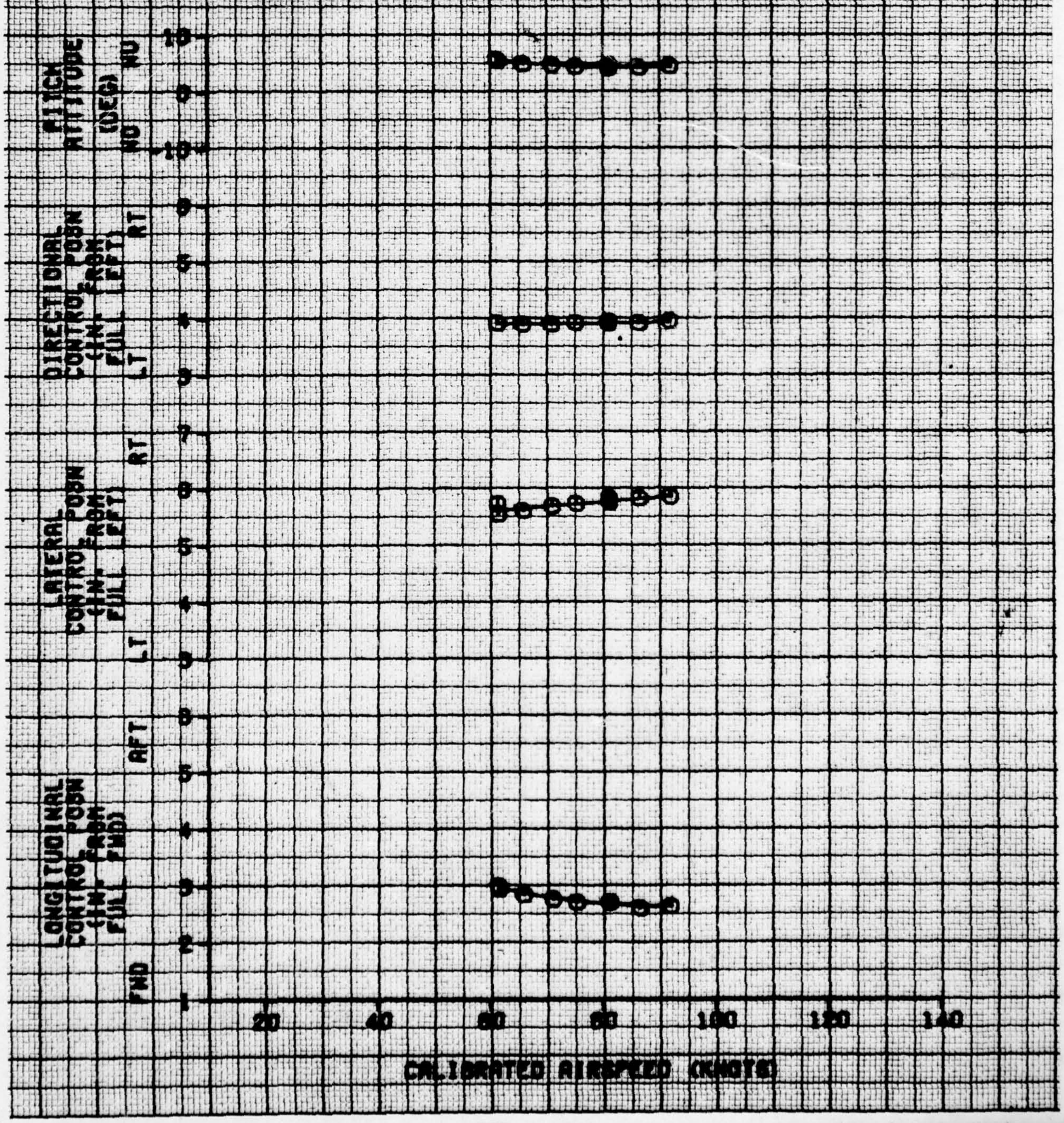


FIGURE 41

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-22330

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
9220	138.9 (AFT)	0.2 (RT)	4920	9.0	322	LEVEL	MULTEMS

NOTE: SHADED SYMBOL DENOTES TRIM.

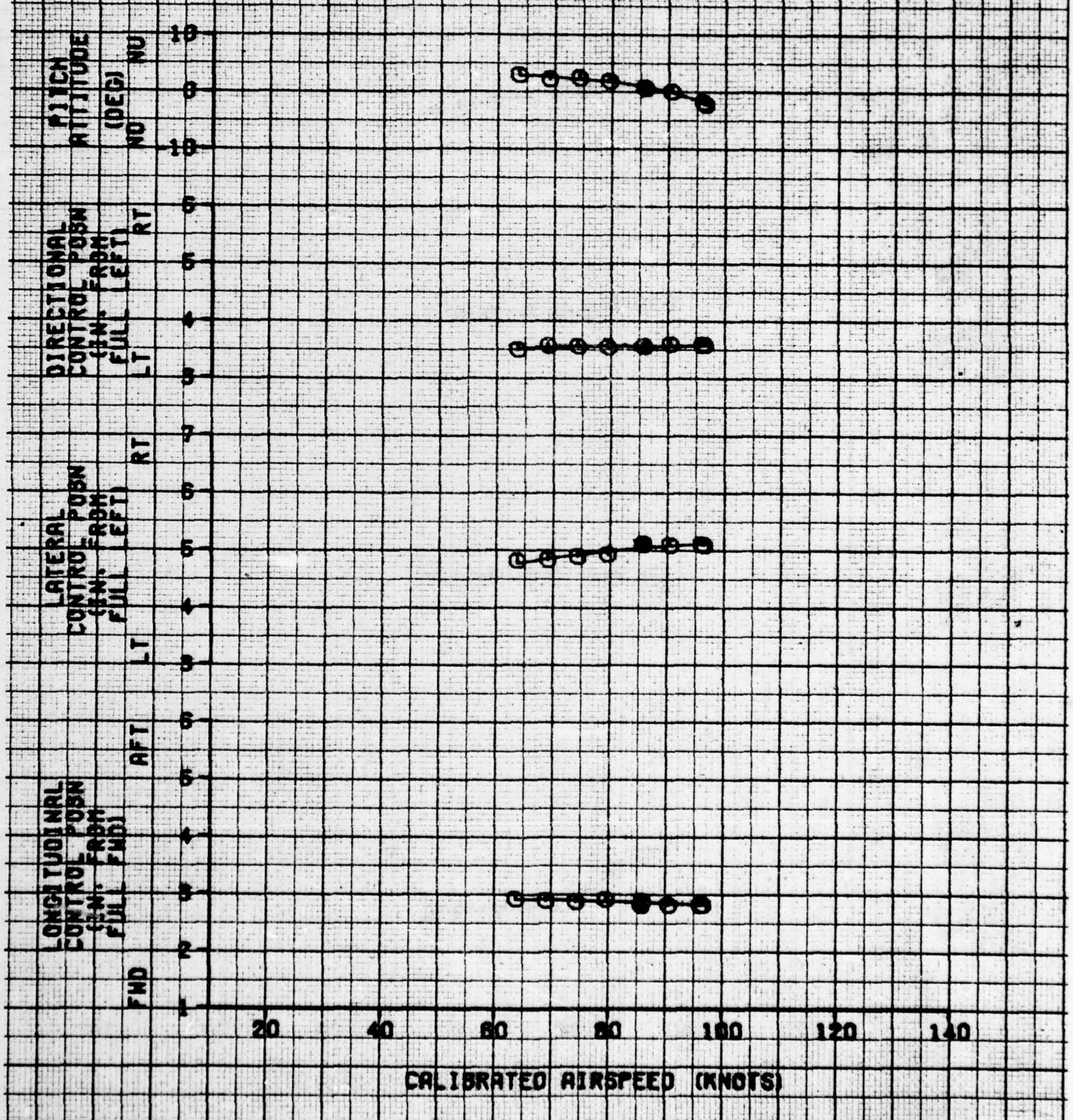


FIGURE 42

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-22356

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
8860	135.0(MID)	0.7(RT)	5480	26.5	324	CLIMB	MULTENS

NOTE: SHADED SYMBOL DENOTES TRIM.

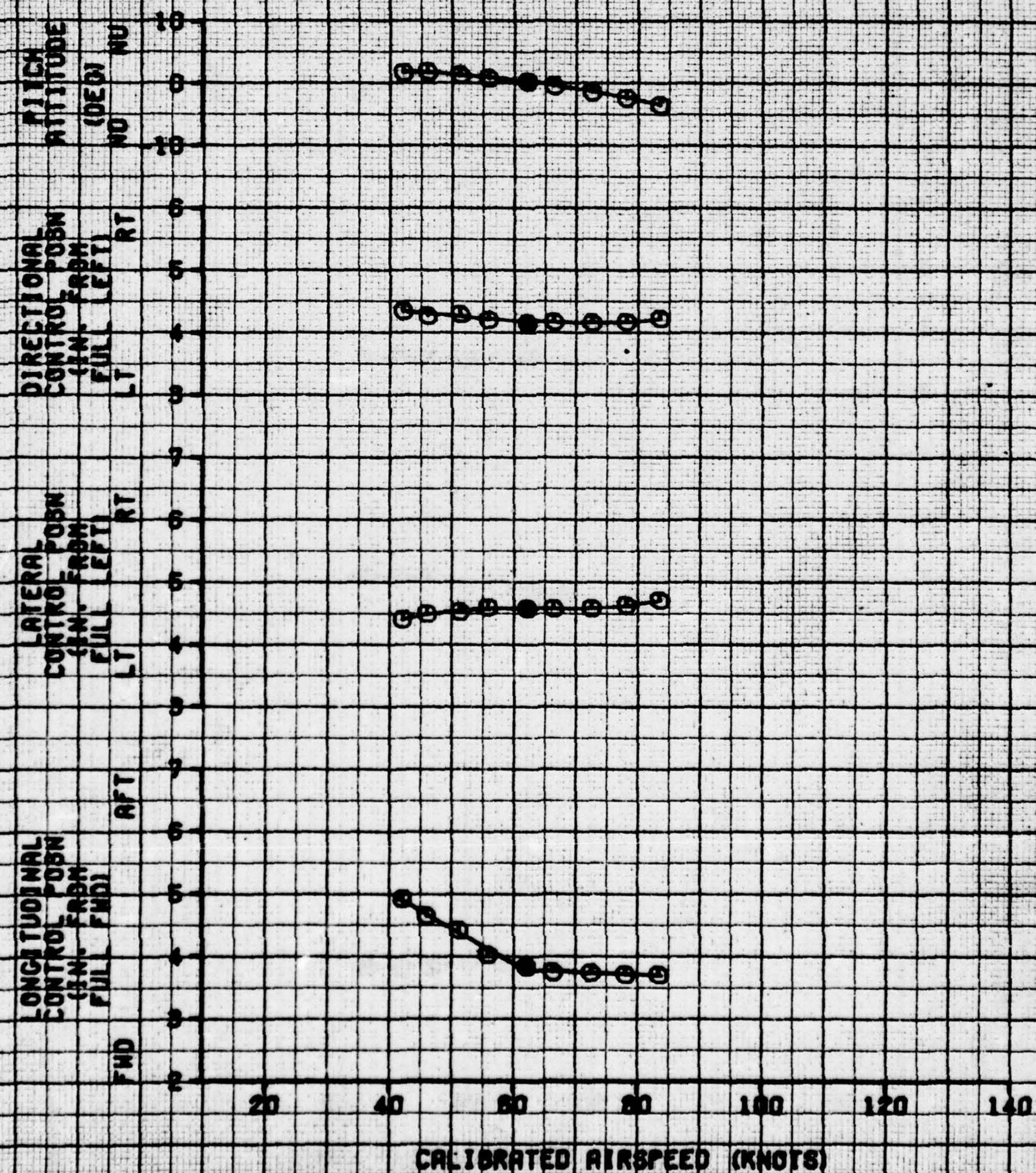


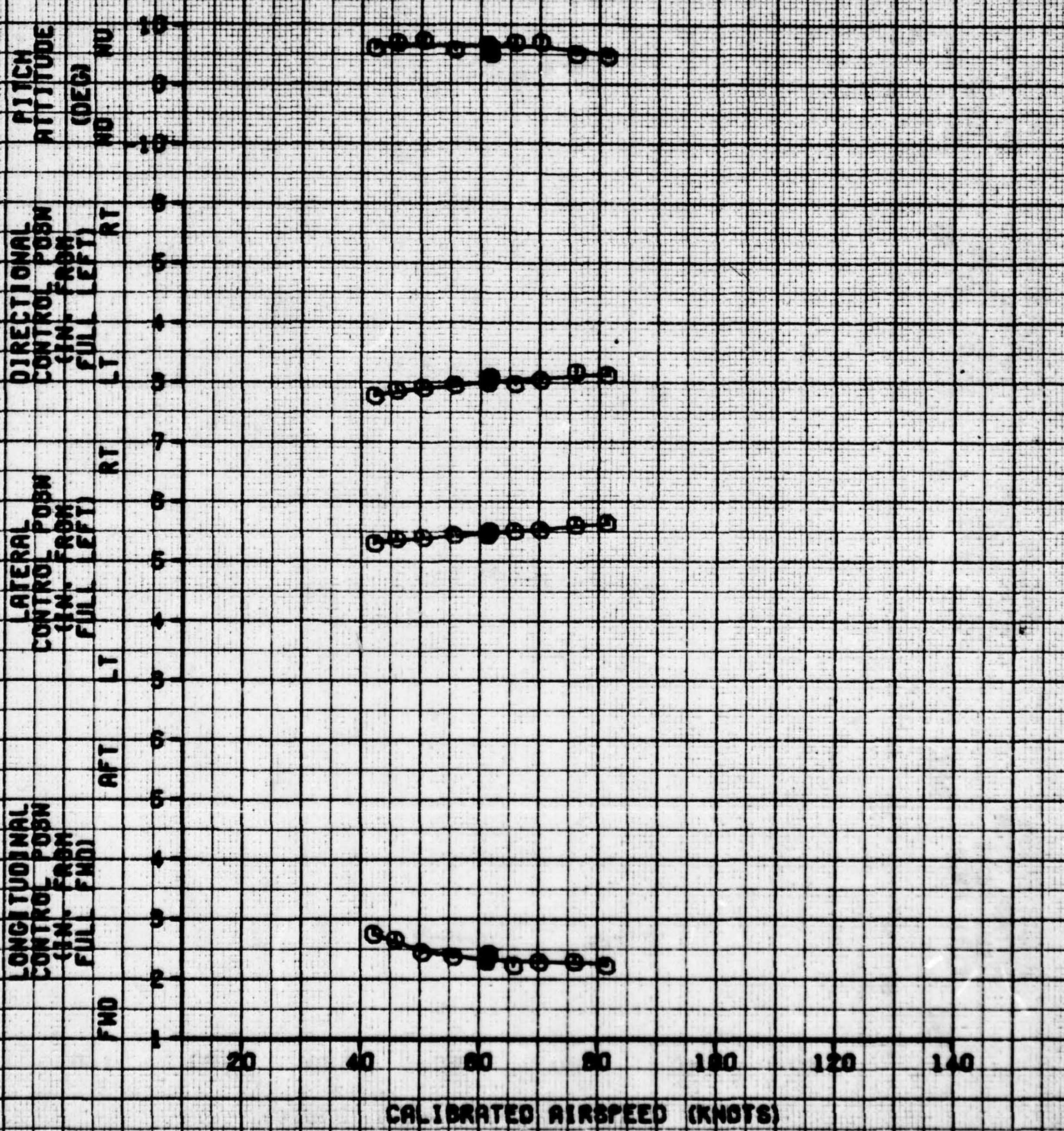
FIGURE 13

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-[illegible]

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
9200	140.0(AFT)	0.4(RT)	7480	12.0	324	CLIMB	CLEAN

NOTE: SHADED SYMBOL DENOTES TRIM.



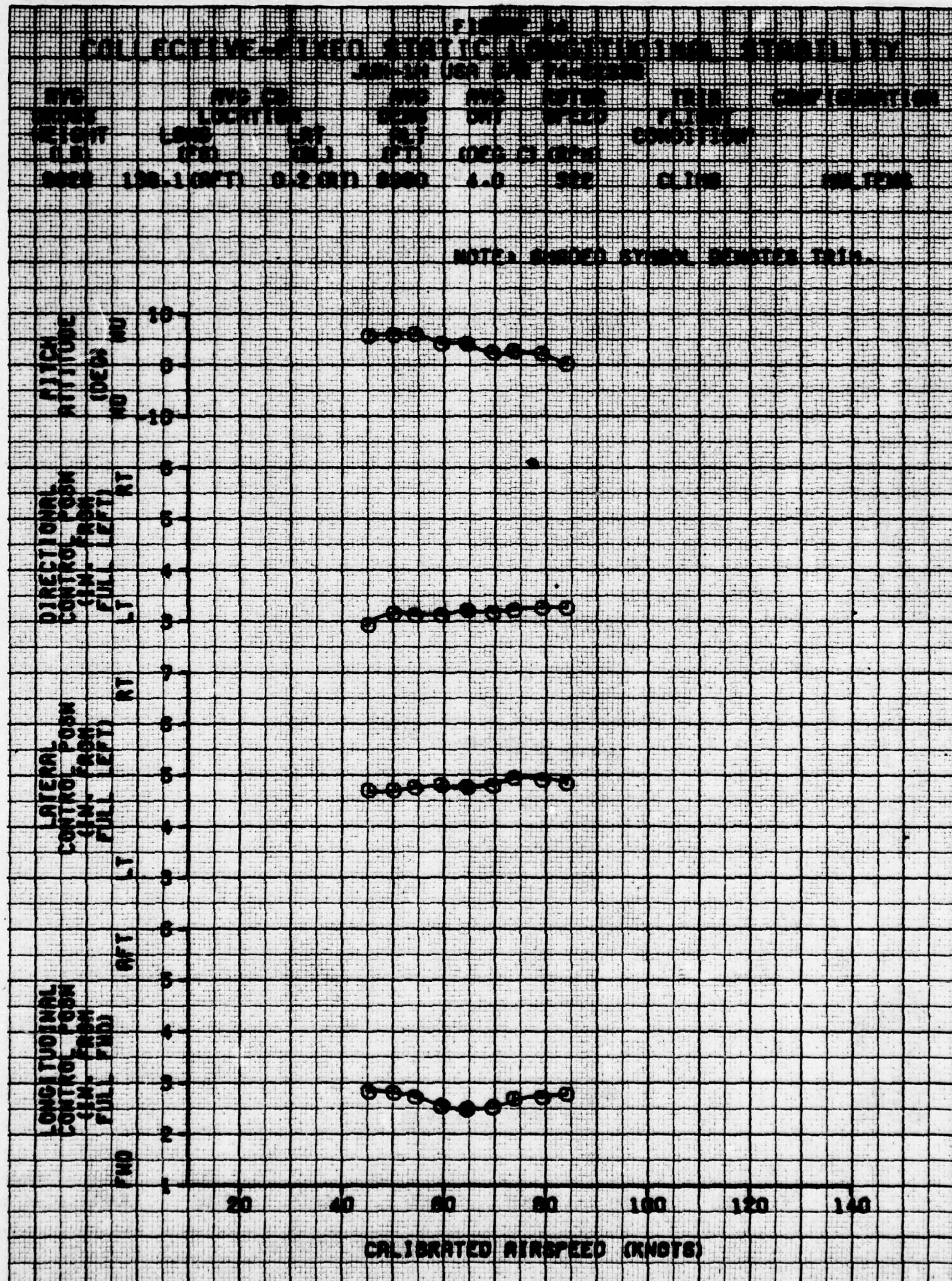

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
CONFIGURATION
LOCATION
CONDITION
CLIMB
NOTE: SHADED SYMBOL DENOTES TRIM.
PITCH ATTITUDE (DEG)
ND
NU
DIRECTIONAL CONTROL POSN (IN. FROM FULL LEFT)
LT
RT
LATERAL CONTROL POSN (IN. FROM FULL LEFT)
LT
RT
LONGITUDINAL CONTROL POSN (IN. FROM FULL FWD)
FWD
AFT
20
40
60
80
100
120
140
CALIBRATED AIRSPEED (KNOTS)

FIGURE 65

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-22356

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
9080	155.4 (MID)	0.7 (RT)	7780	18.0	317	AUTO	MULTEMS

NOTE: SHADED SYMBOL DENOTES TRIM.

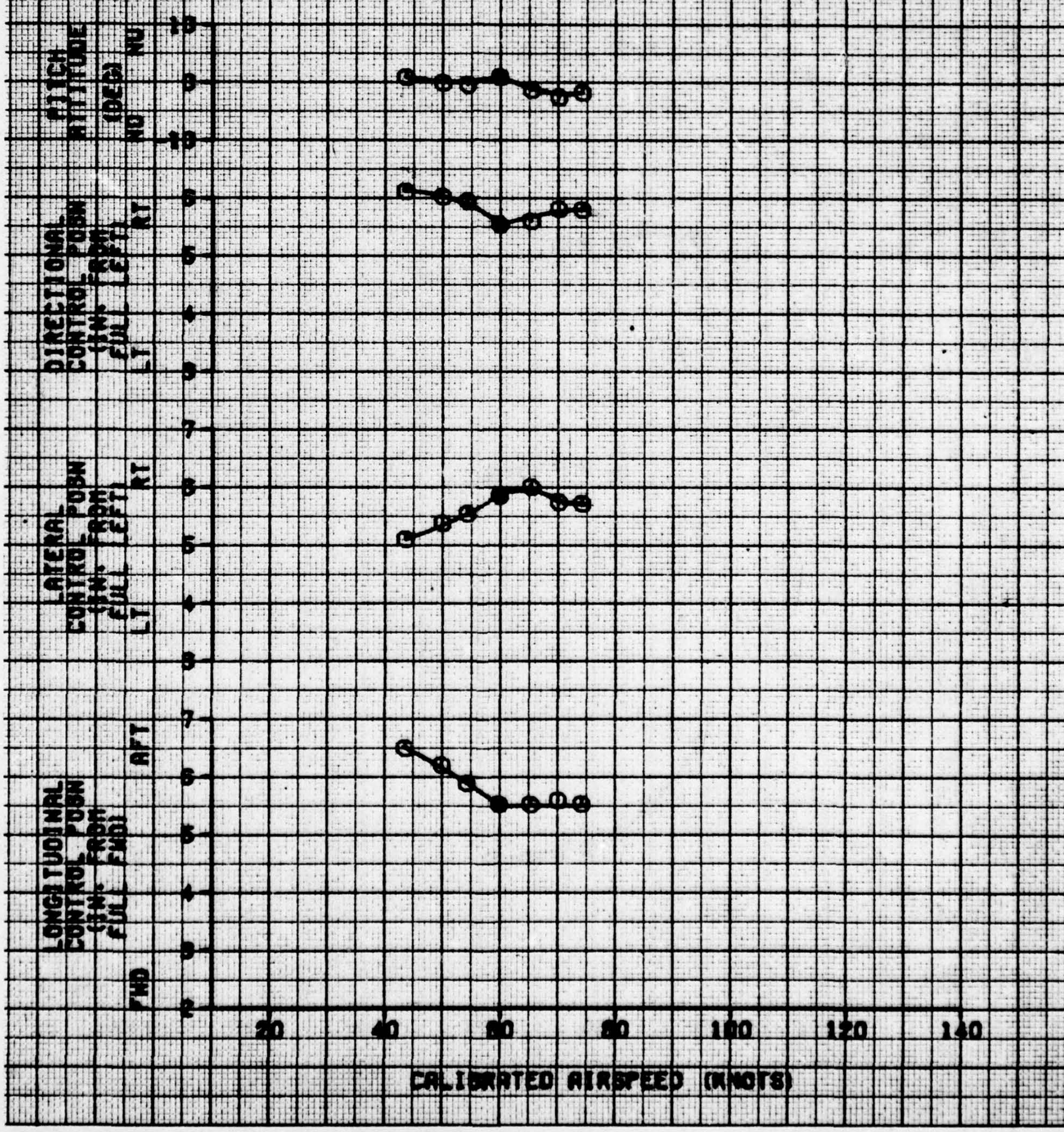


FIGURE 46

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-22356

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
8140	139.8 (AFT)	0.4 (RT)	7060	11.5	318	AUTO	CLEAN

NOTE: SHADED SYMBOL DENOTES TRIM.

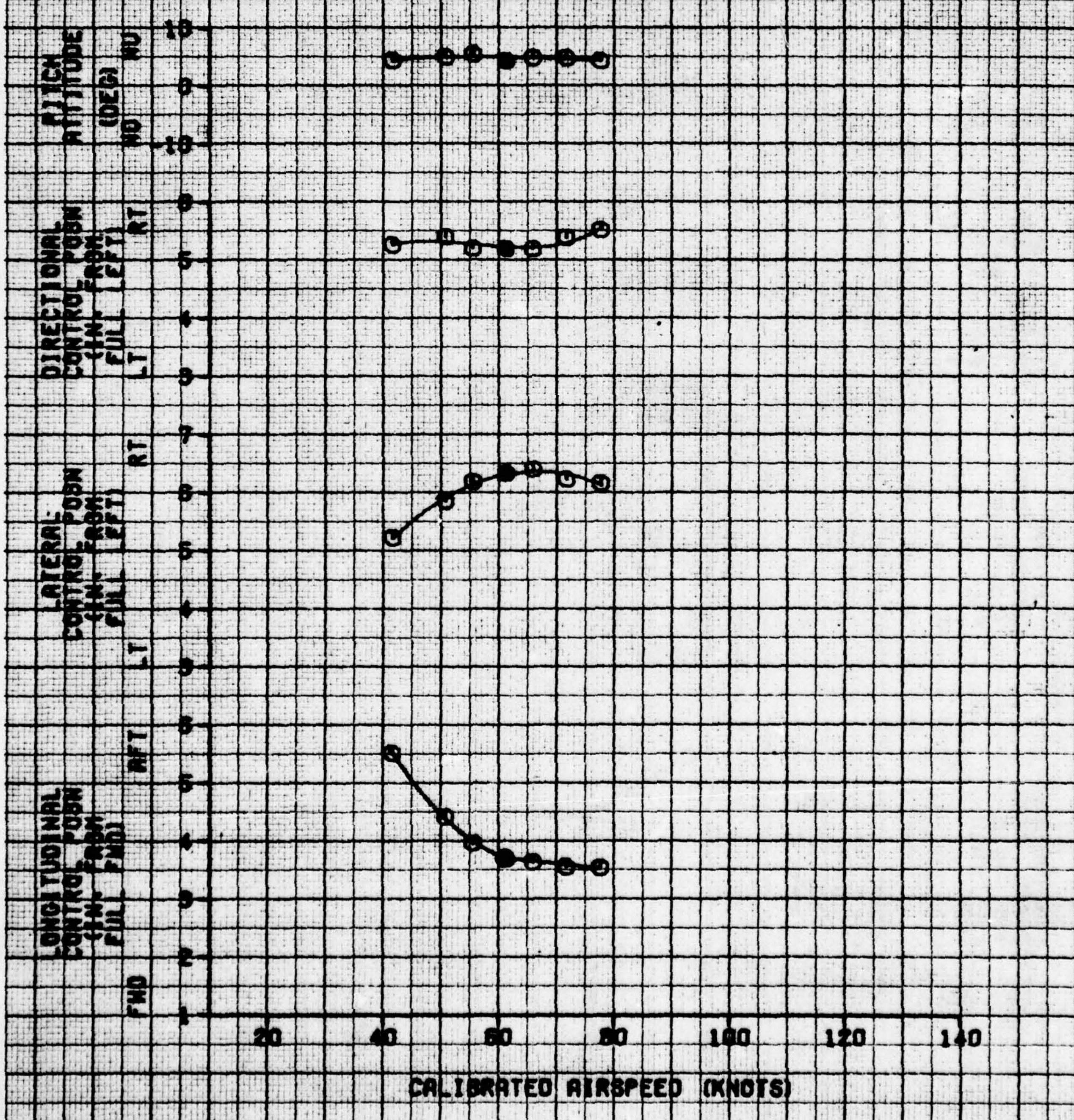
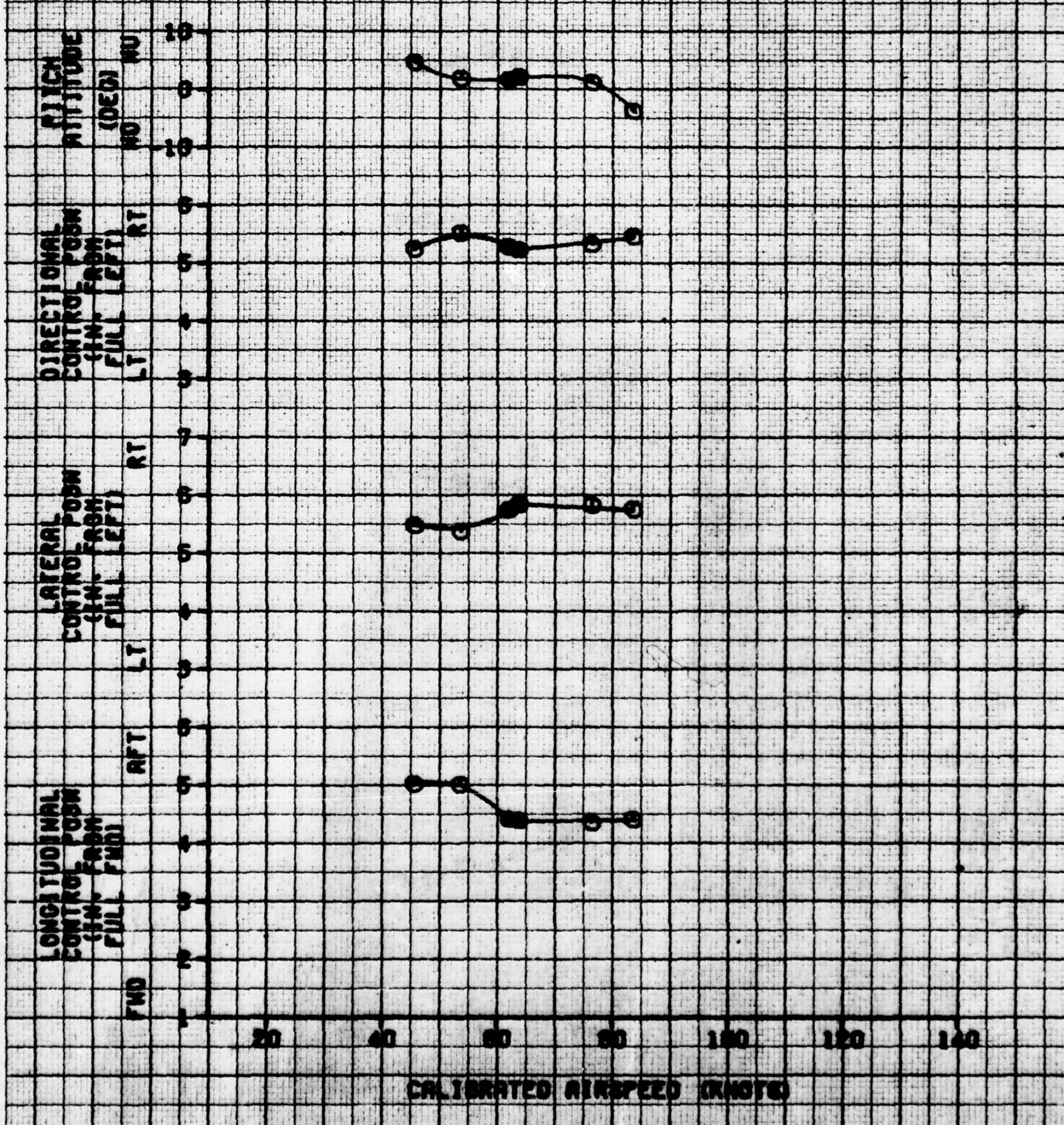


FIGURE 47
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
JUH-1H USA S/N 74-22330

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
8900	138.7 (AFT)	0.2 (RT)	8360	5.0	316	AUTO	MULTEMS

NOTE: SHADED SYMBOL DENOTES TRIM.



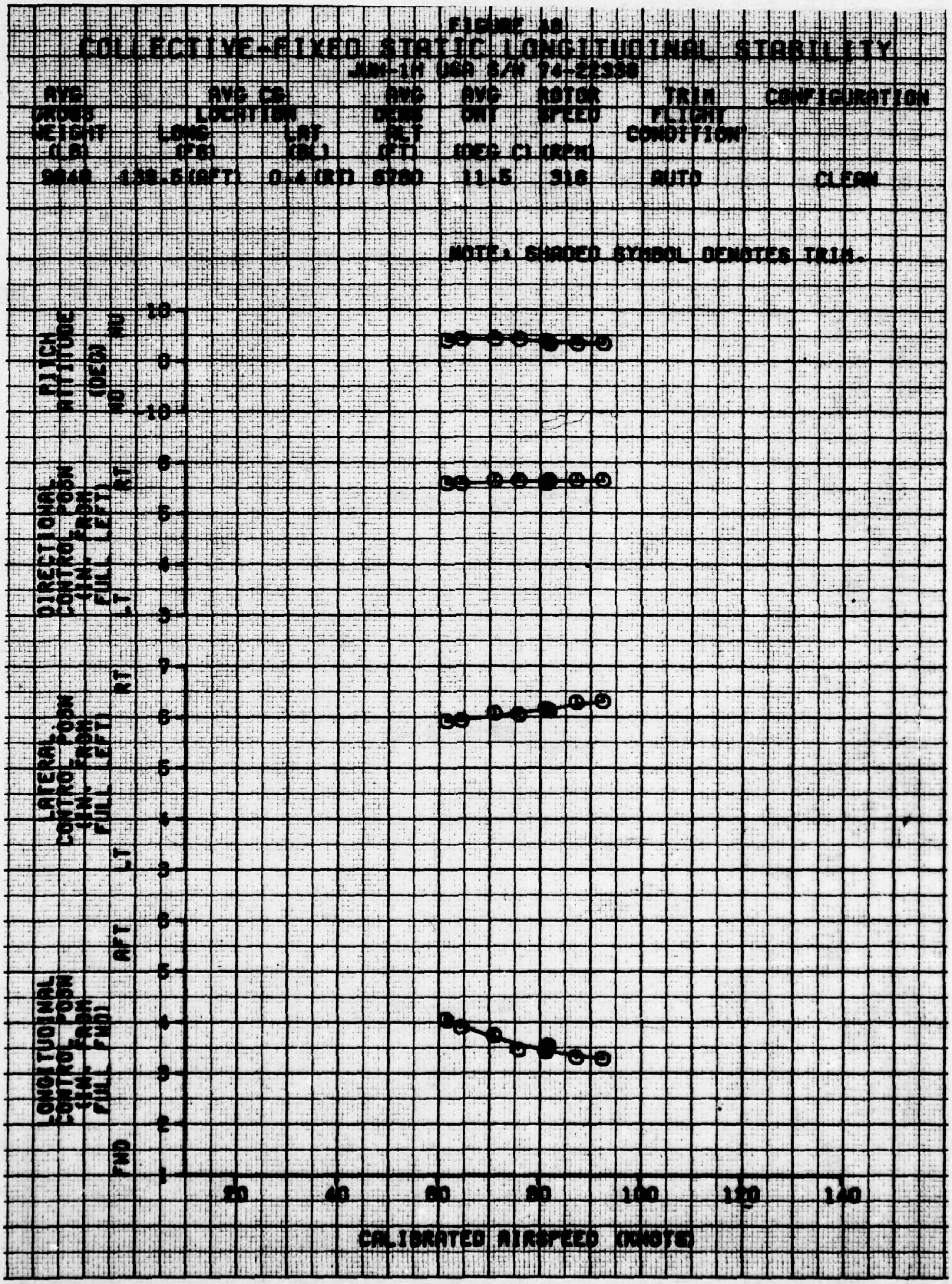


FIGURE 18
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
JAH-1H USA S/N 74-22338
AVG GROSS WEIGHT (LB)
AVG CG LOCATION LONG (FS) LAT (BL)
AVG DENS ALT (FT)
AVG OAT (DEG C)
ROTOR SPEED (RPM)
TRIM FLIGHT CONDITION
CONFIGURATION
9840 139.5(AFT) 0.4(RT) 6780 11.5 318 AUTO CLEAN
NOTE: SHADED SYMBOL DENOTES TRIM.
PITCH ATTITUDE (DEG)
ND
NU
DIRECTIONAL CONTROL POSN (IN. FROM FULL LEFT)
LATERAL CONTROL POSN (IN. FROM FULL LEFT)
LT
RT
LONGITUDINAL CONTROL POSN (IN. FROM FULL FWD)
FWD
AFT
CALIBRATED AIRSPEED (KNOTS)

FIGURE 49

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	CONFIGURATION
8700	136.4(AFT)	0.2 (RT)	6060	5.5	318	AUTO	MULTEMS

NOTE: SHADED SYMBOL DENOTES TRIM.

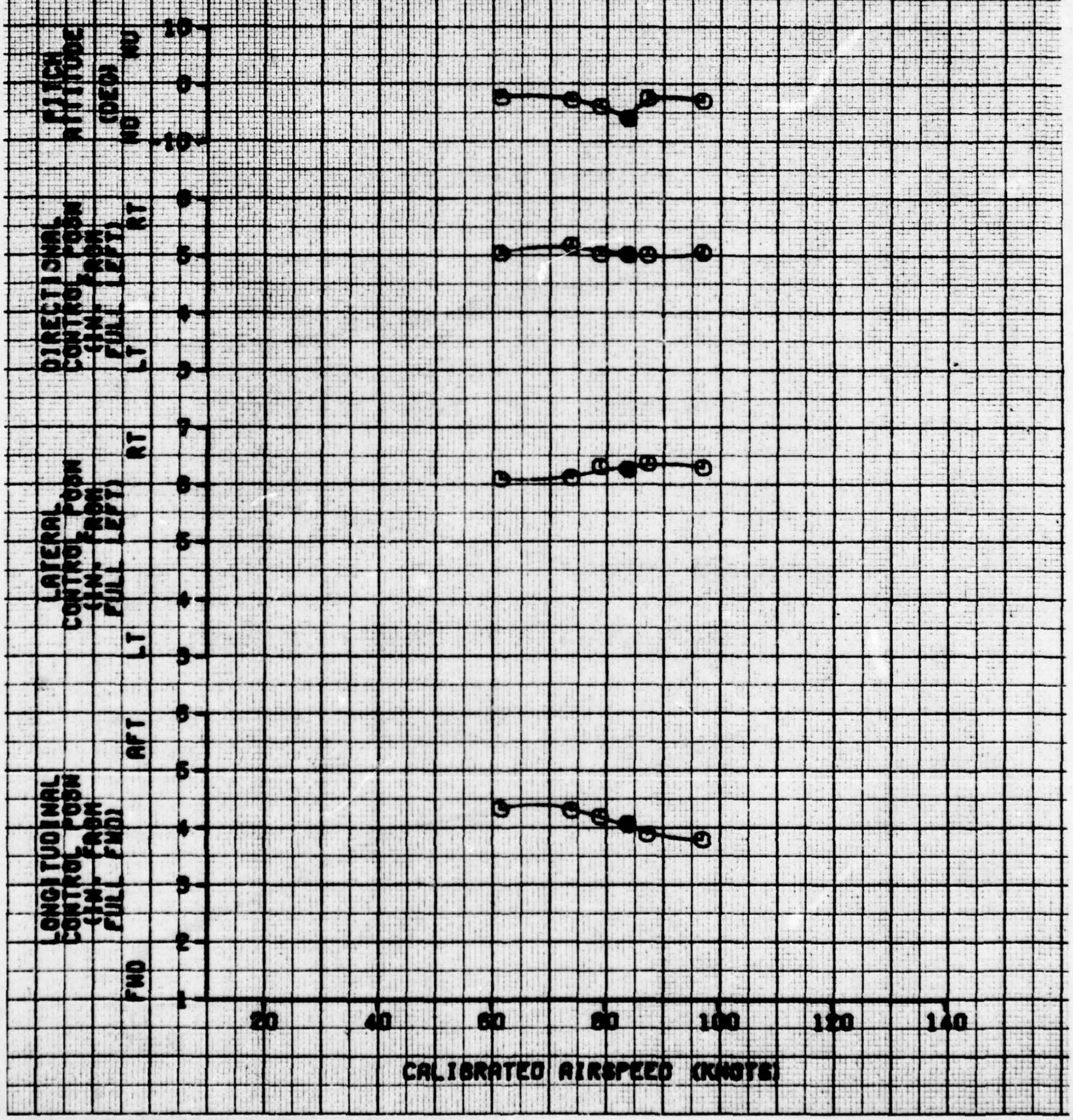


FIGURE 50
STATIC LATERAL-DIRECTIONAL STABILITY
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
9220	136.0(MID)	0.7(RT)	6020	24.0	324	63	LEVEL

NOTES: 1. SHADED SYMBOLS DENOTE TRIM.
2. MULTEWS CONFIGURATION.

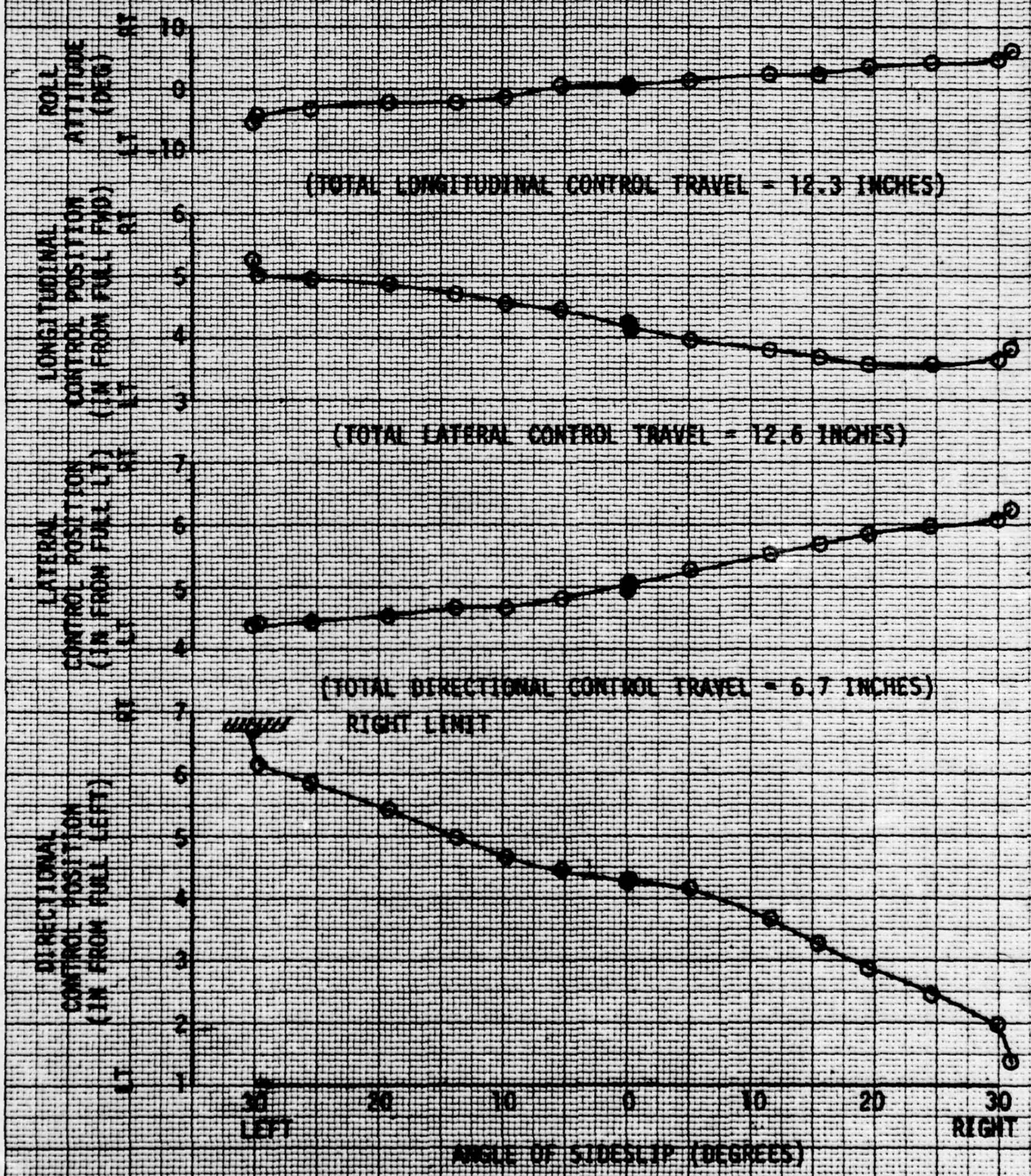


FIGURE 51
STATIC LATERAL-DIRECTIONAL STABILITY
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
9020	135.3(MID)	0.7(RT)	5360	24.0	328	83	LEVEL

NOTES: 1. SHADED SYMBOLS DENOTE TRIM.
2. MULTEMS CONFIGURATION.

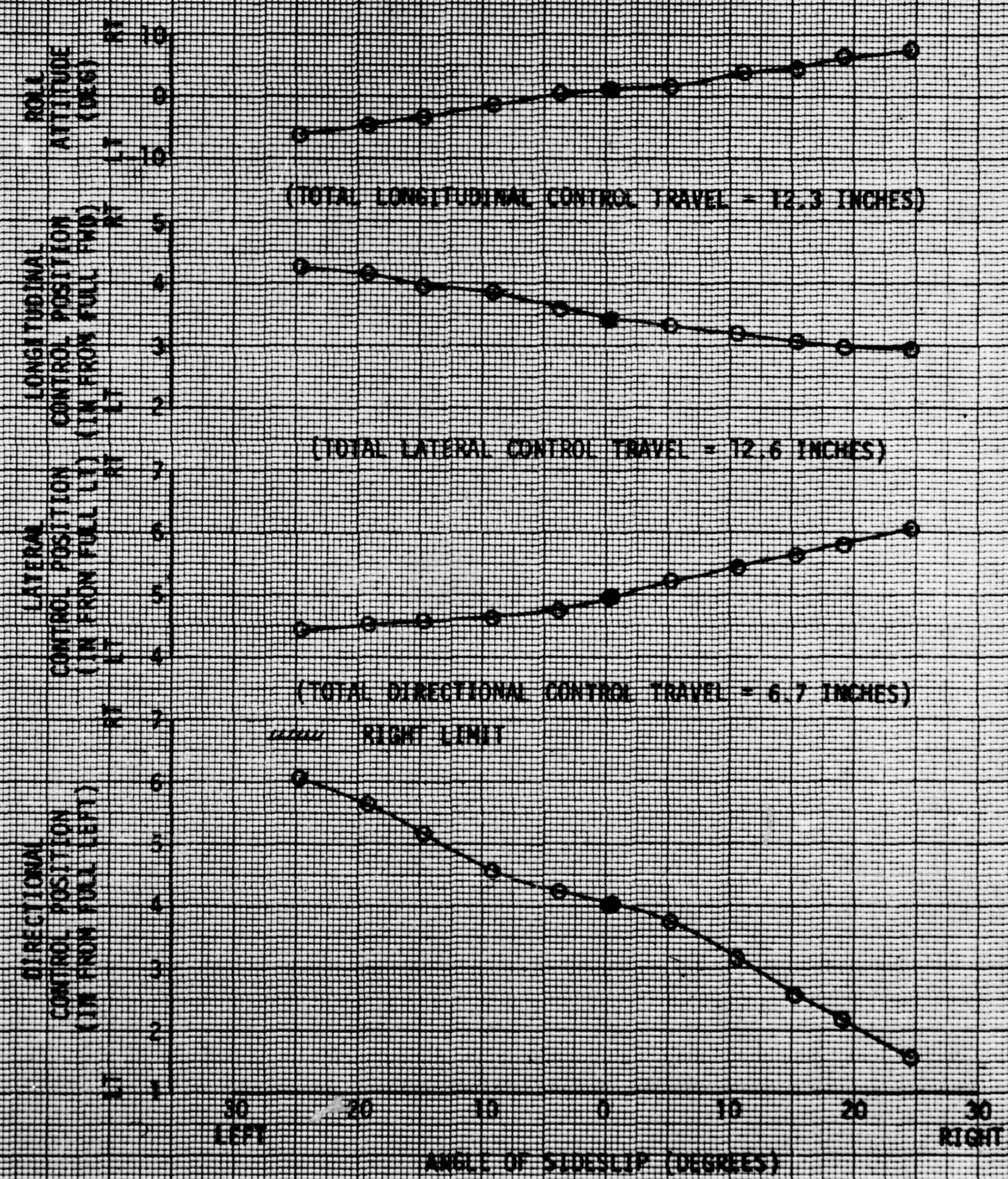


FIGURE 82
MANEUVERING STABILITY
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	OUTSIDE AIR TEMPERATURE (°C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED (KT)	CONFIGURATION
9260	136.8(MID)	0.7(RT)	5840	24.5	324	63	MULTEMS

NOTES: 1. DATA OBTAINED IN WIND-UP TURNS.
2. SHADED SYMBOLS DENOTE TRIM.
3. CIRCLES DENOTE RIGHT TURNS.
4. SQUARES DENOTE LEFT TURNS.

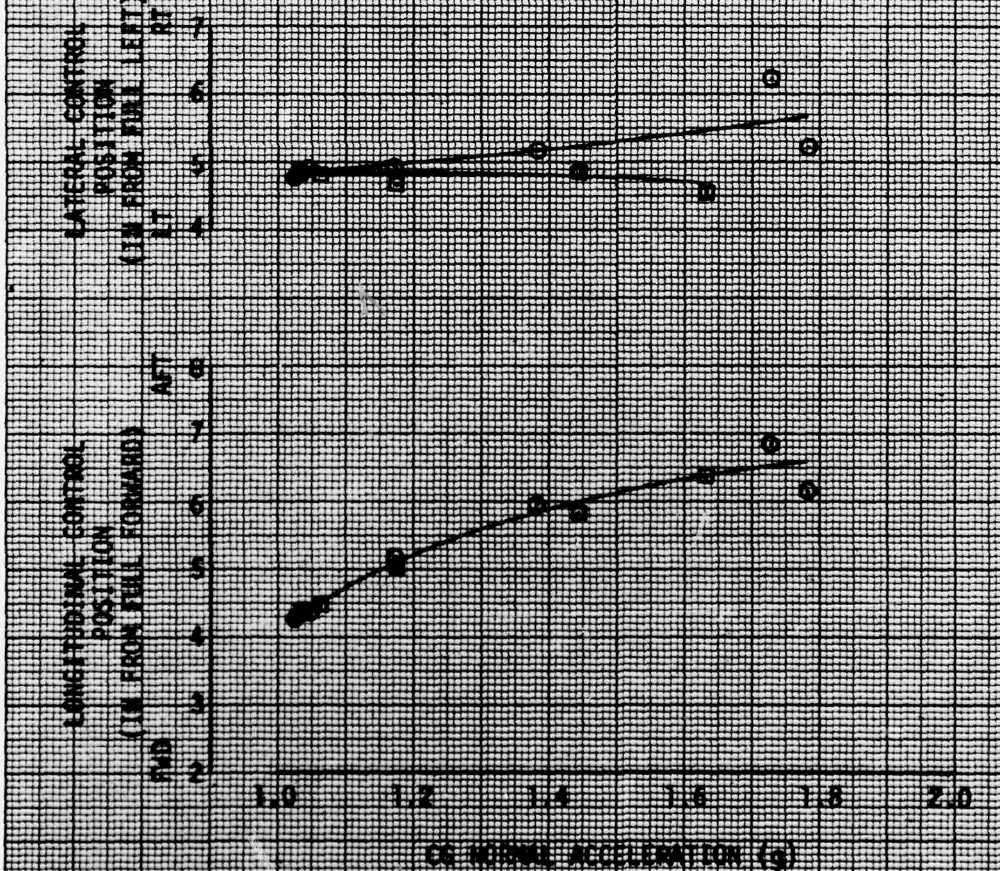


FIGURE 53
MANEUVERING STABILITY
JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	OUTSIDE AIR TEMPERATURE (°C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED (KT)	CONFIGURATION
9000	135.9(MID)	.7(RT)	5920	24.5	324	78	MULTEWS

NOTES:
1. DATA OBTAINED IN WIND-UP TURNS.
2. SHADED SYMBOLS DENOTE TRIM.
3. CIRCLES DENOTE RIGHT TURNS.
4. SQUARES DENOTE LEFT TURNS.

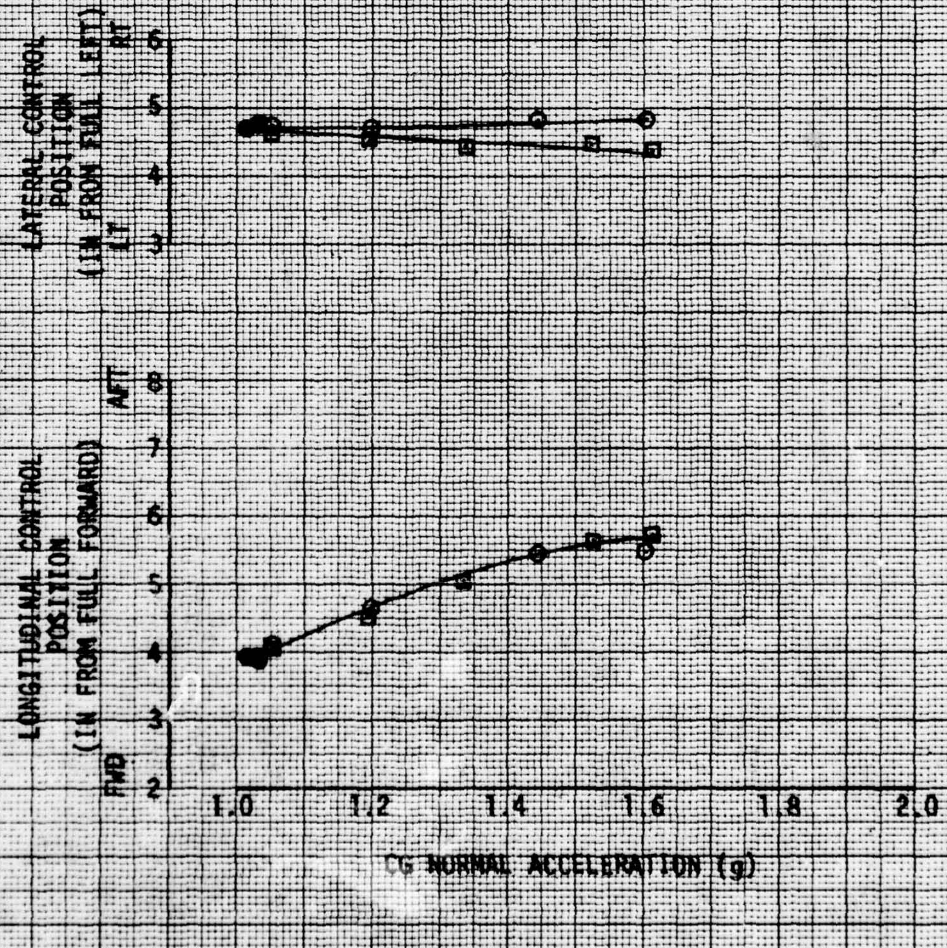


FIGURE 54

LATERAL SHORT PERIOD RESPONSE

JUH-1H USA S/N 74-22338

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	ENTRY CALIBRATED AIRSPEED (KT)
8940	135.7 (MID)	0.7 (RT)	6080	22.5	324	81

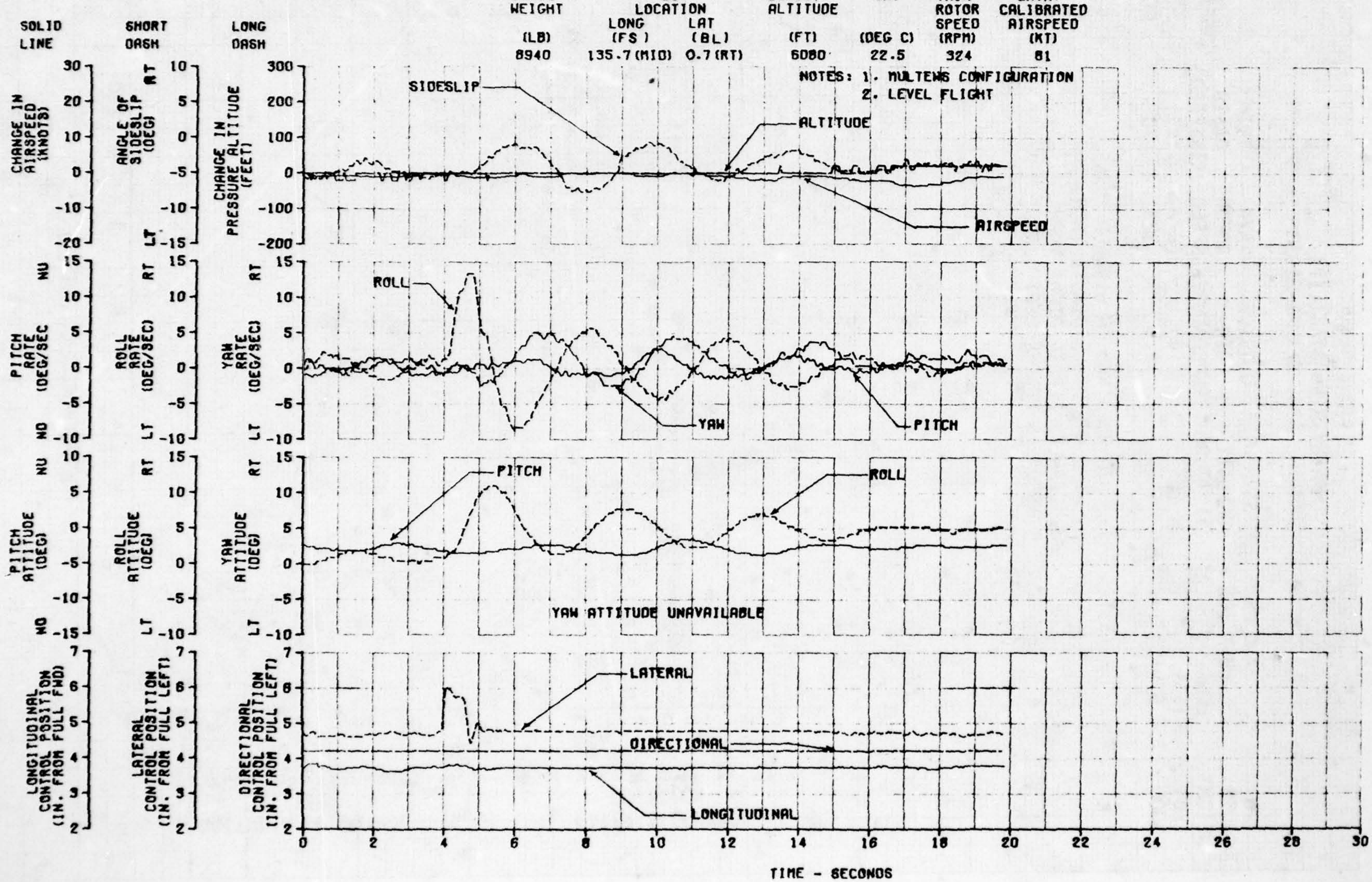


FIGURE 55

LONGITUDINAL LONG PERIOD RESPONSE

JUH-1H USA S/N 74-22338

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	ENTRY CALIBRATED AIRSPEED (KT)
9080	136.2 (MID)	0.7 (RT)	5900	23.5	323	60

SOLID LINE   SHORT DASH   LONG DASH

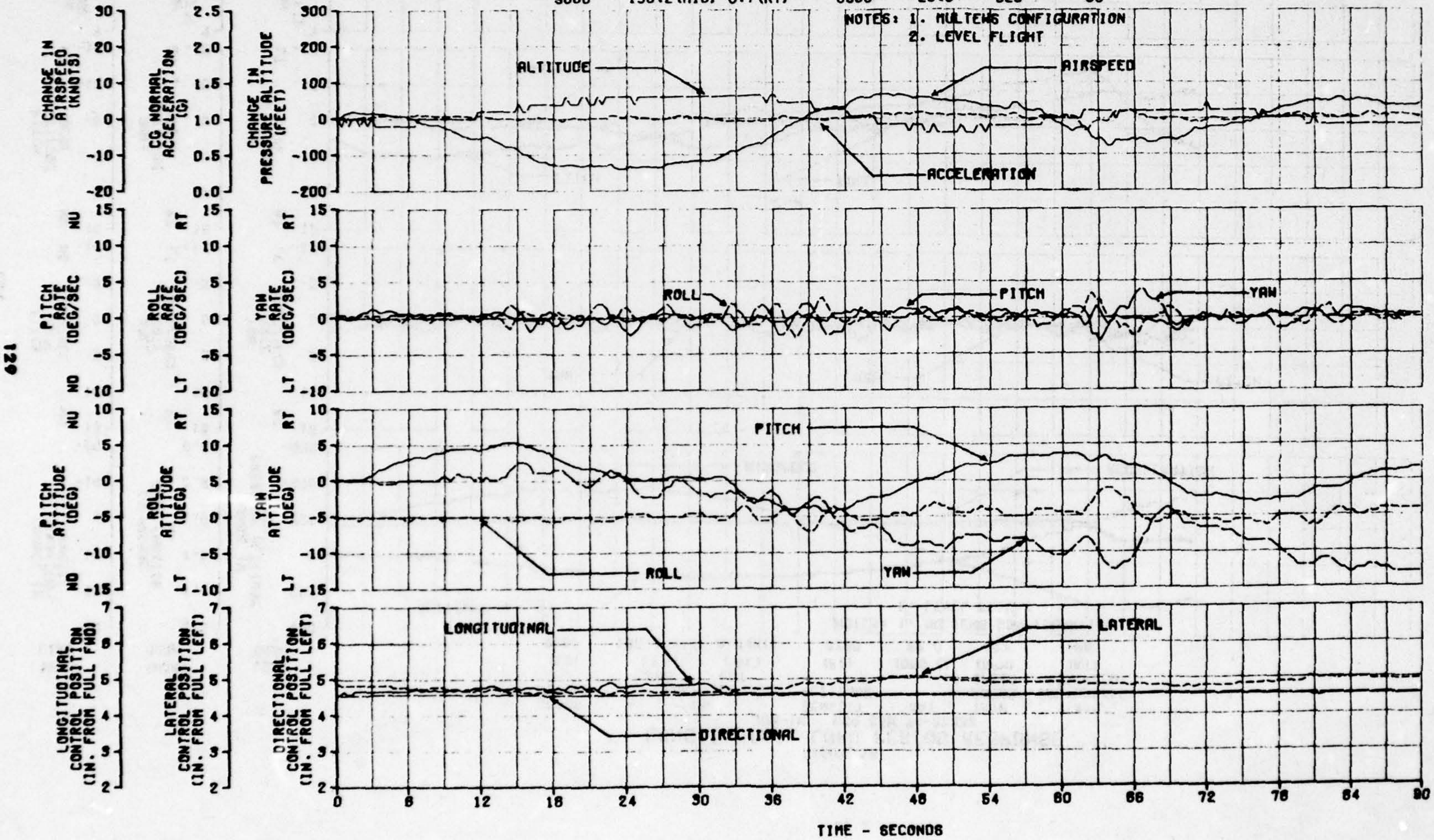


FIGURE 56
LONGITUDINAL LONG PERIOD RESPONSE
JUH-1H USA S/N 74-22336

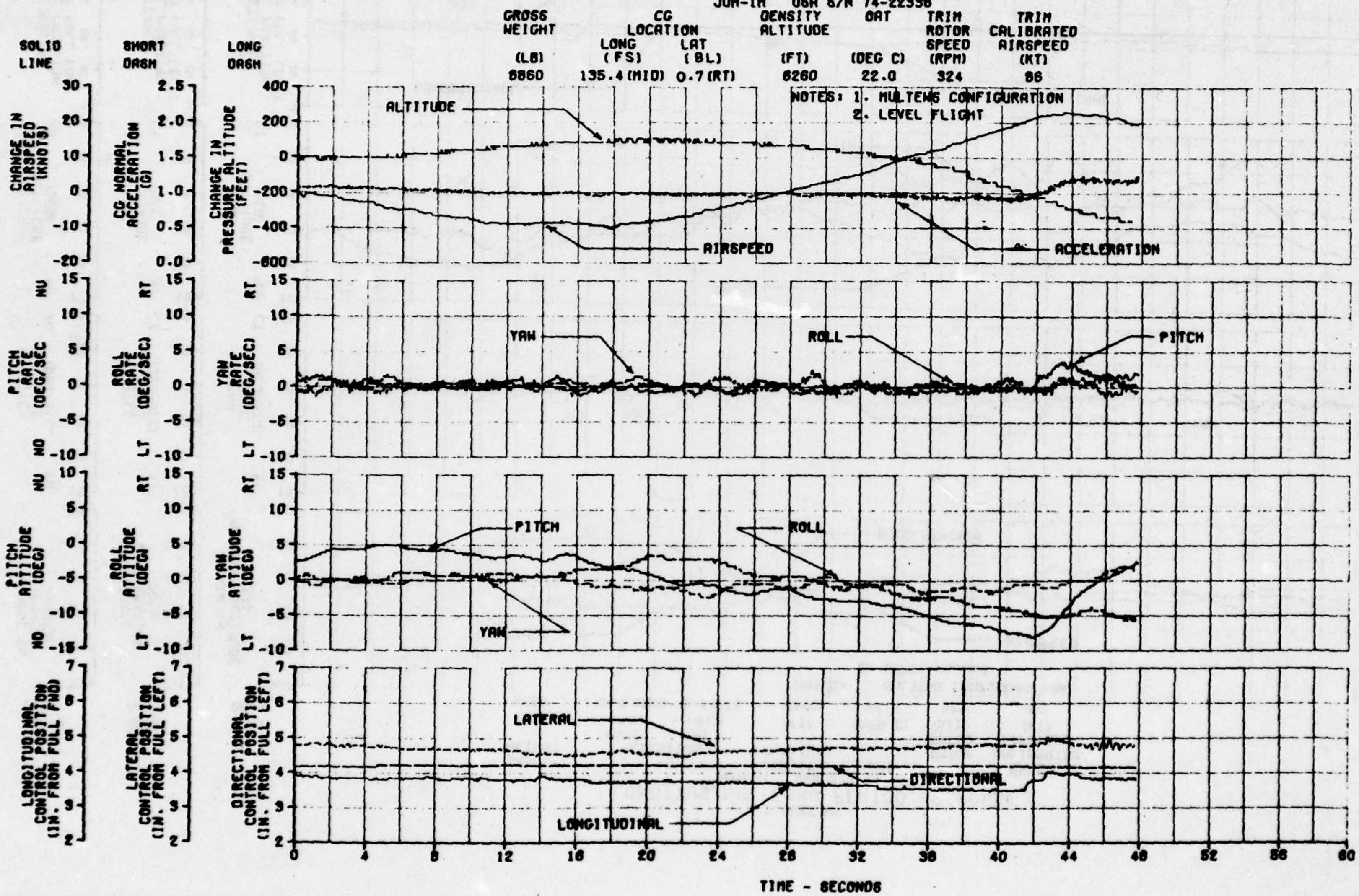


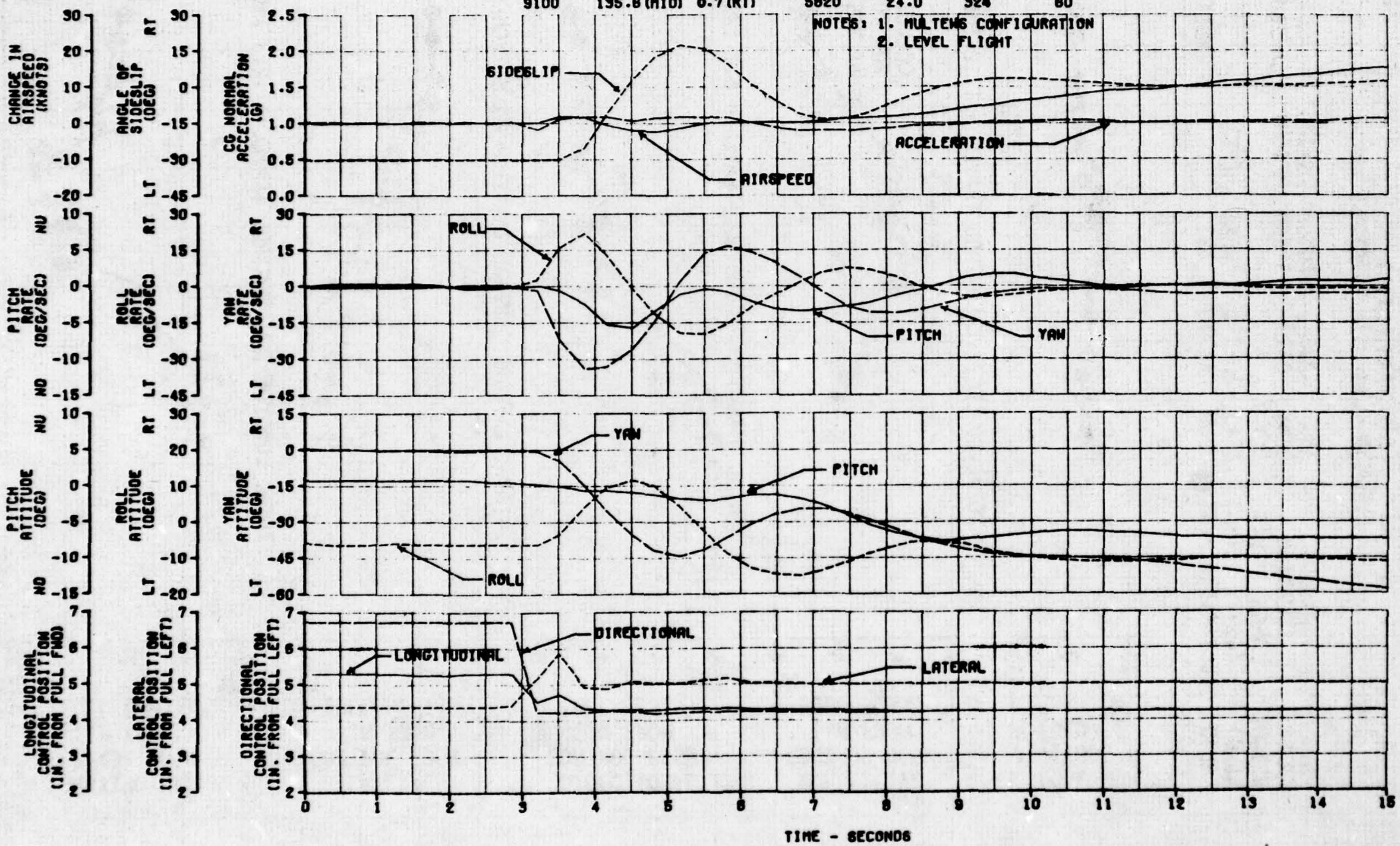
FIGURE 57

SUDDEN RELEASE FROM STEADY HEADING SIDESLIP

JUH-1H USA S/N 74-22338

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	ENTRY CALIBRATED AIRSPEED (KT)
9100	135.6 (MID)	0.7 (RT)	5820	24.0	324	60

NOTES: 1. MULTEMS CONFIGURATION
2. LEVEL FLIGHT



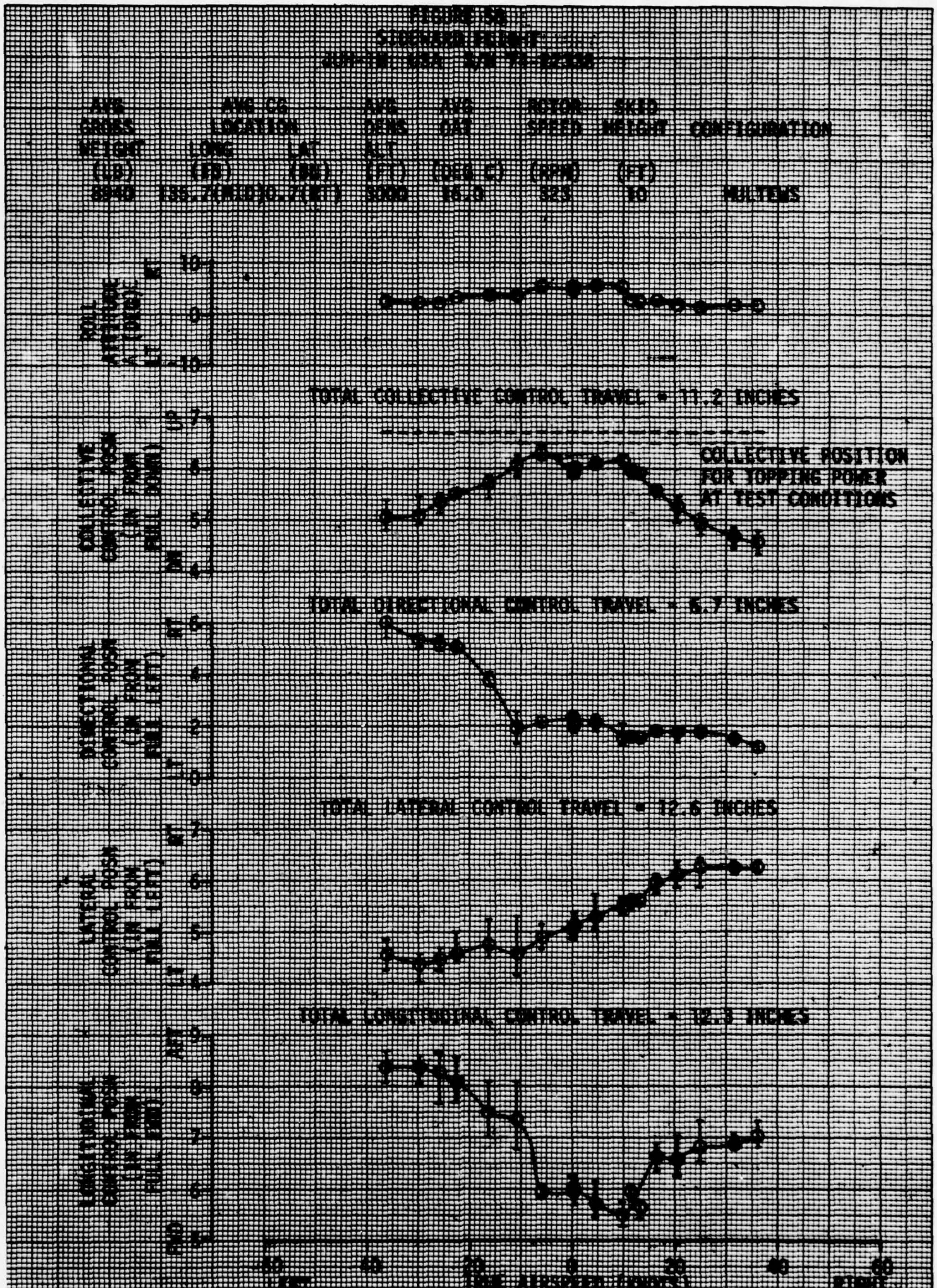

AVG GROSS WEIGHT (LB) 8940
AVG CG LOCATION LONG (FS) 136.7(MID) LAT (BL) 0.7(RT)
AVG DENS ALT (FT) 3000
AVG OAT (DEG C) 16.0
ROTOR SPEED (RPM) 323
SKID HEIGHT (FT) 10
CONFIGURATION MULTEWS
TOTAL COLLECTIVE CONTROL TRAVEL = 11.2 INCHES
COLLECTIVE POSITION FOR TOPPING POWER AT TEST CONDITIONS
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.7 INCHES
TOTAL LATERAL CONTROL TRAVEL = 12.6 INCHES
TRUE AIRSPEED (KNOTS)
LEFT
RIGHT

FIGURE 59

LOW-SPEED FORWARD AND REARWARD FLIGHT

JUH-1H USA S/N 74-22338

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (IN)	AVG CG LOCATION LAT (IN)	AVG DENS ALT (FT)	AVG OAT (DEG C)	ROTOR SPEED (RPM)	SKID HEIGHT (FT)	CONFIGURATION
9220	136.7(MID)	.7(RT)	2880	15.5	321	10	MULTEWS

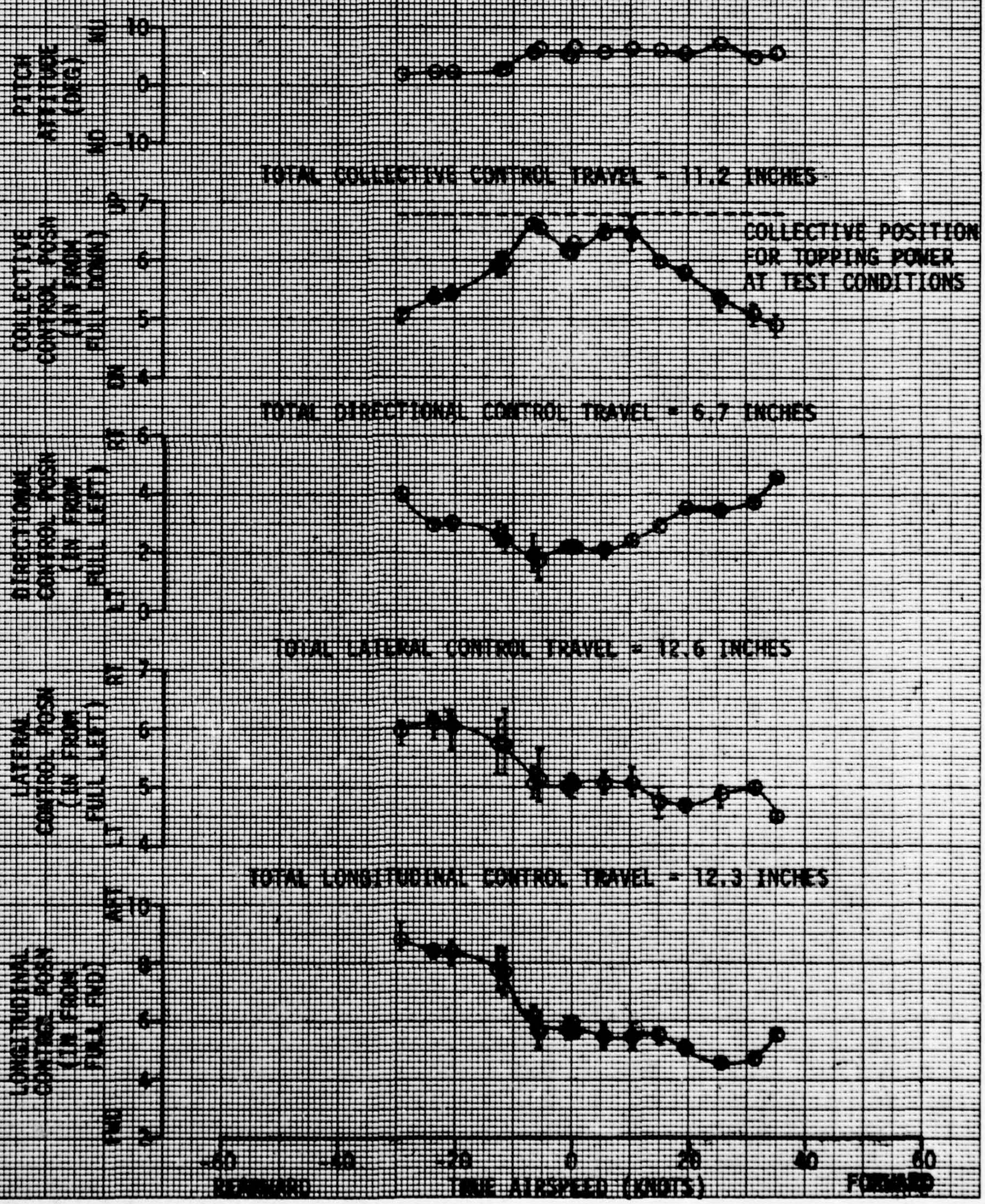


FIGURE 60

SIMULATED ENGINE FAILURE

JUH-1H USA S/N 74-22338

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION
9240	136.9 (MID)	0.7 (RT)	6720	22.0	324	67	LEVEL FLIGHT

NOTE: MULTENS CONFIGURATION

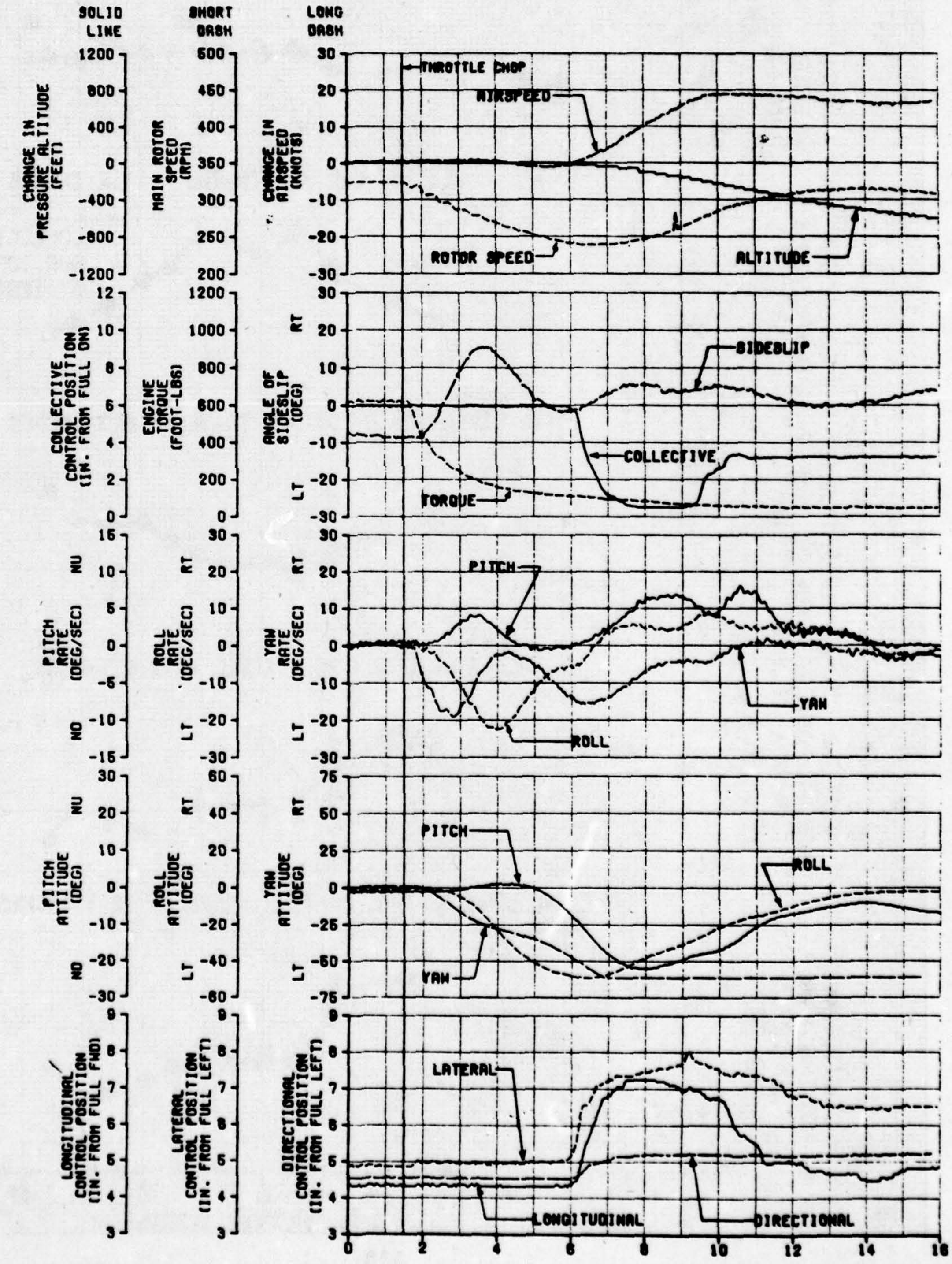
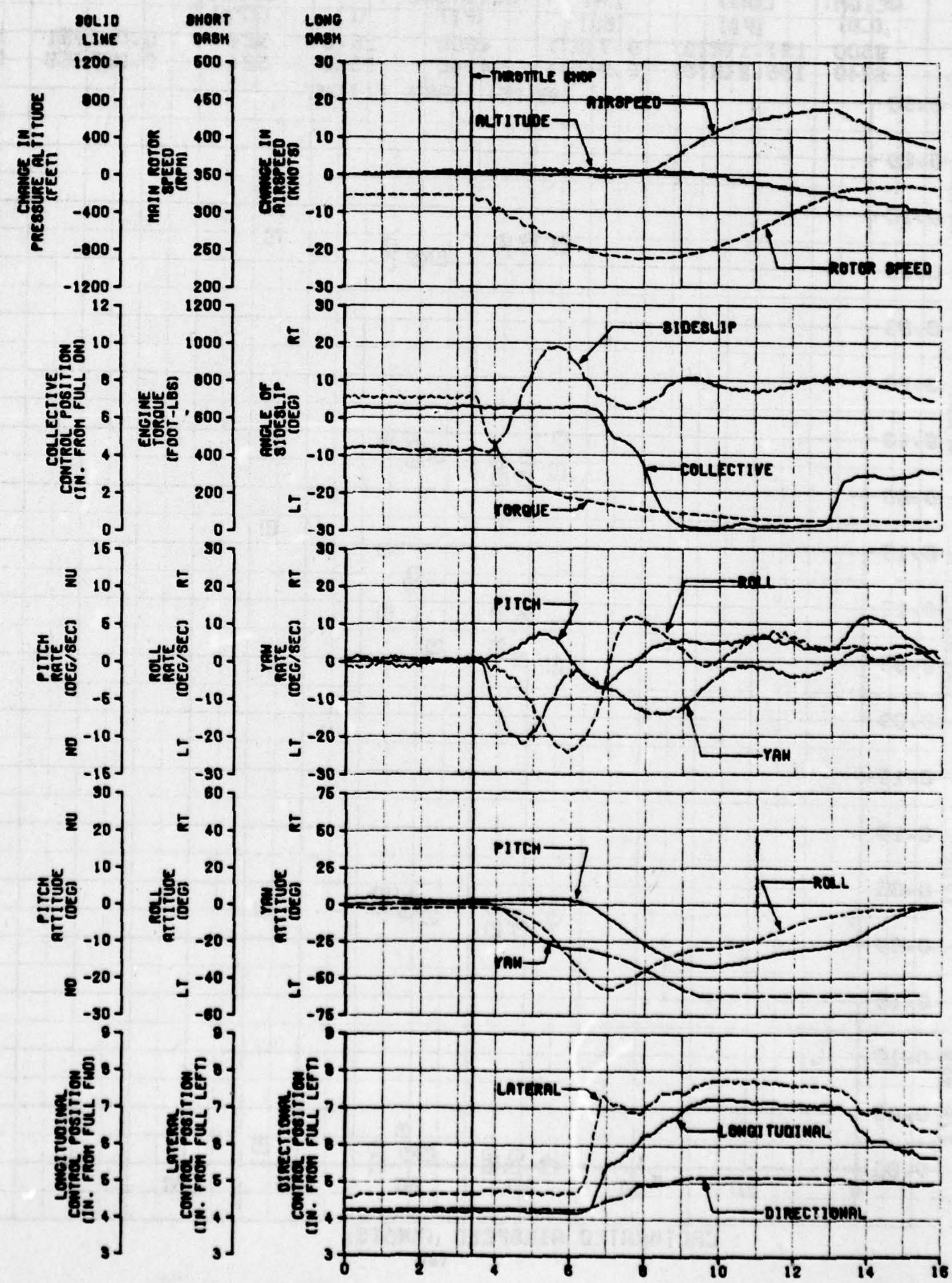


FIGURE 61
SIMULATED ENGINE FAILURE
JUH-1H USA S/N 74-22330

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION
8200	135.8 (MID)	0.7 (RT)	6940	22.5	324	67	CLIMBING FLIGHT

NOTE: MULTENS CONFIGURATION



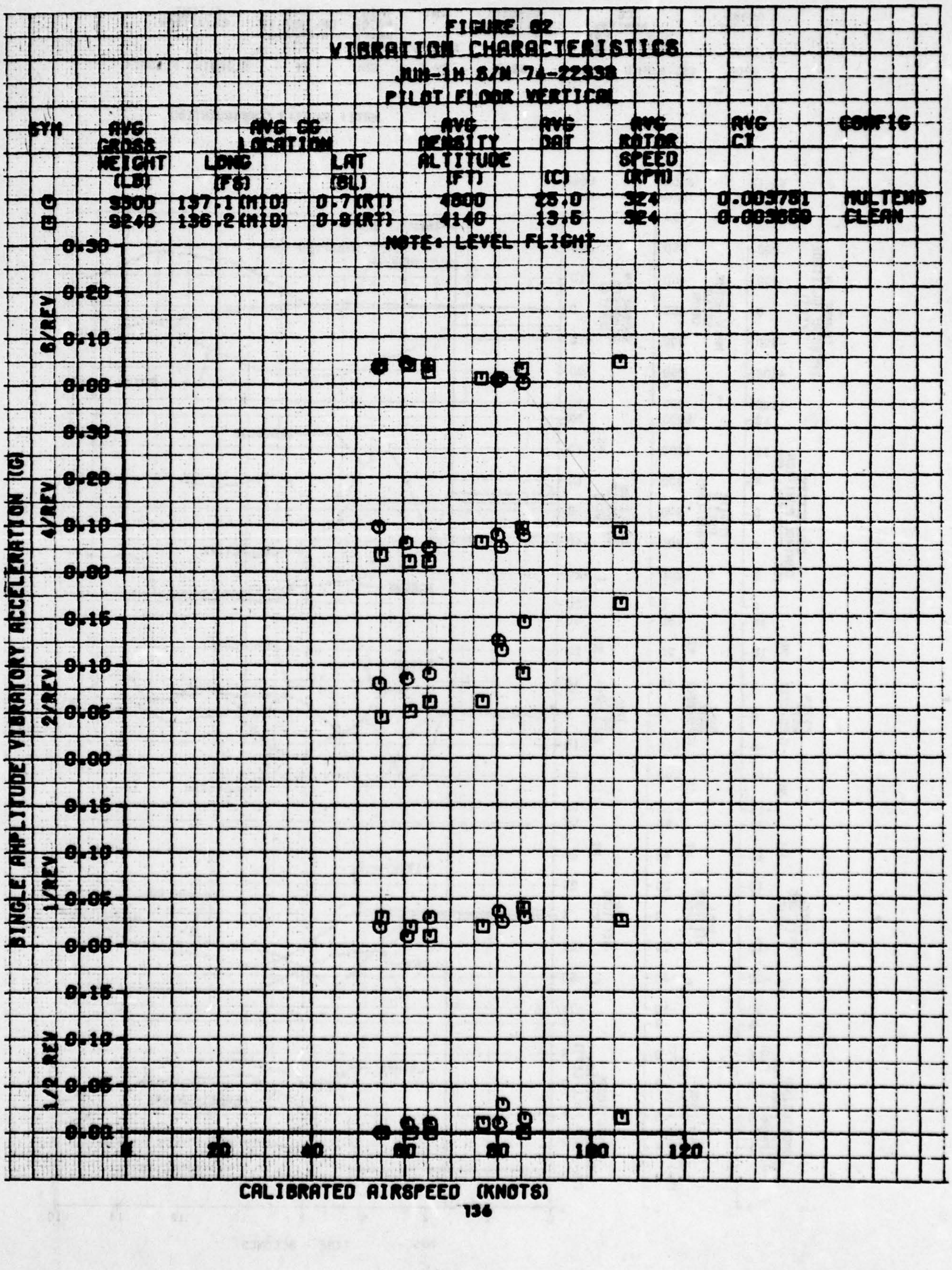
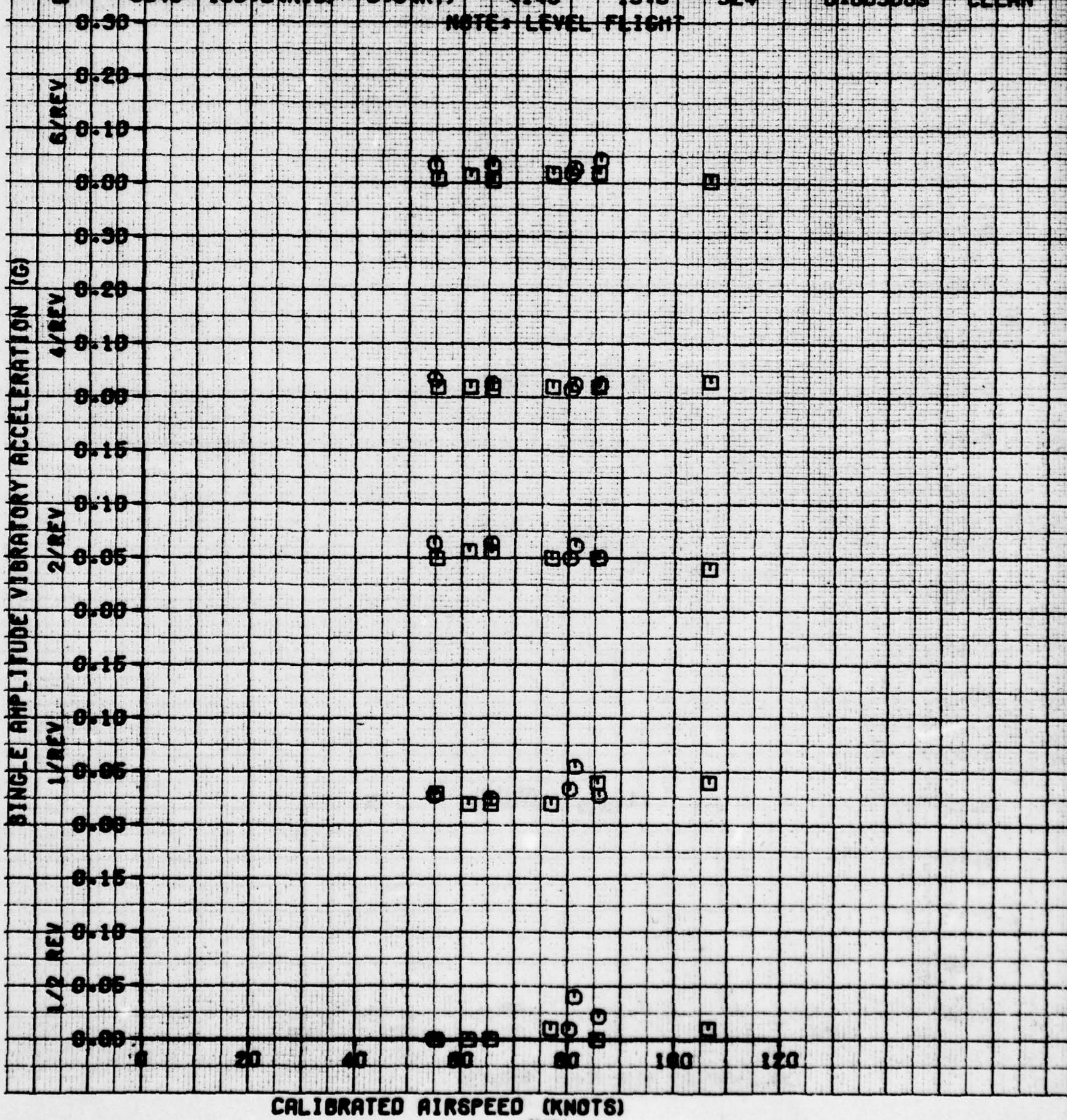


FIGURE 82
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
PILOT FLOOR VERTICAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9300 137.1(MID) 0.7(RT) 4800 25.0 324 0.003781 MULTEMS
9240 136.2(MID) 0.8(RT) 4140 13.5 324 0.003660 CLEAN
NOTE: LEVEL FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.15
0.10
0.05
0.00
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

FIGURE 63
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
PILOT FLOOR LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIG
⊙	9500	137.1(MID)	0.7(RT)	4800	25.0	324	0.003761	MULTEMS
⊡	9240	136.2(MID)	0.9(RT)	4140	13.5	324	0.003669	CLEAN

NOTE: LEVEL FLIGHT



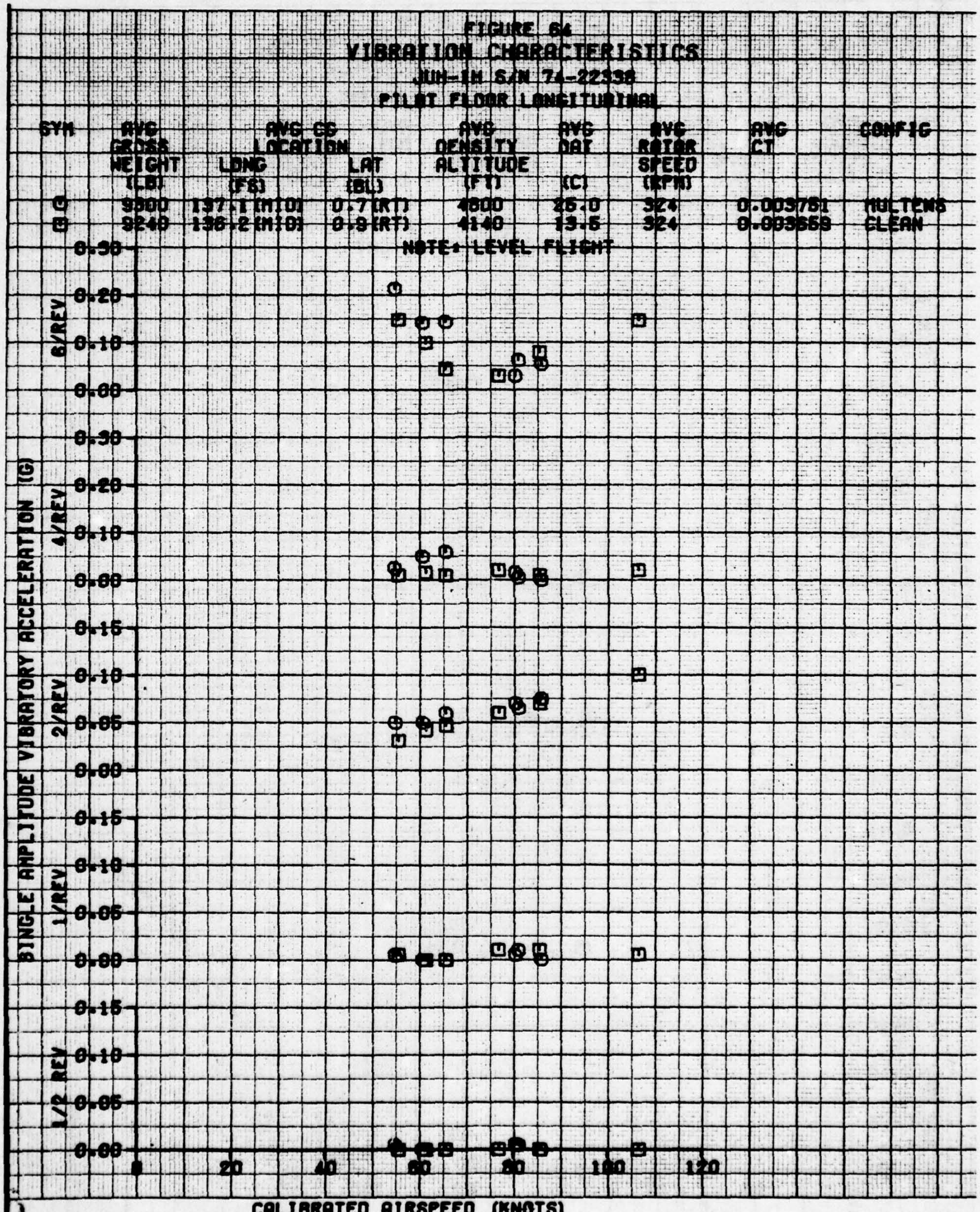


FIGURE 64
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
PILOT FLOOR LONGITUDINAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9300 137.1(MID) 0.7(RT) 4800 25.0 324 0.003751 MULTENS
9240 136.2(MID) 0.8(RT) 4140 13.5 324 0.003659 CLEAN
NOTE: LEVEL FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.00
0.05
0.10
0.15
0.20
0.30
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

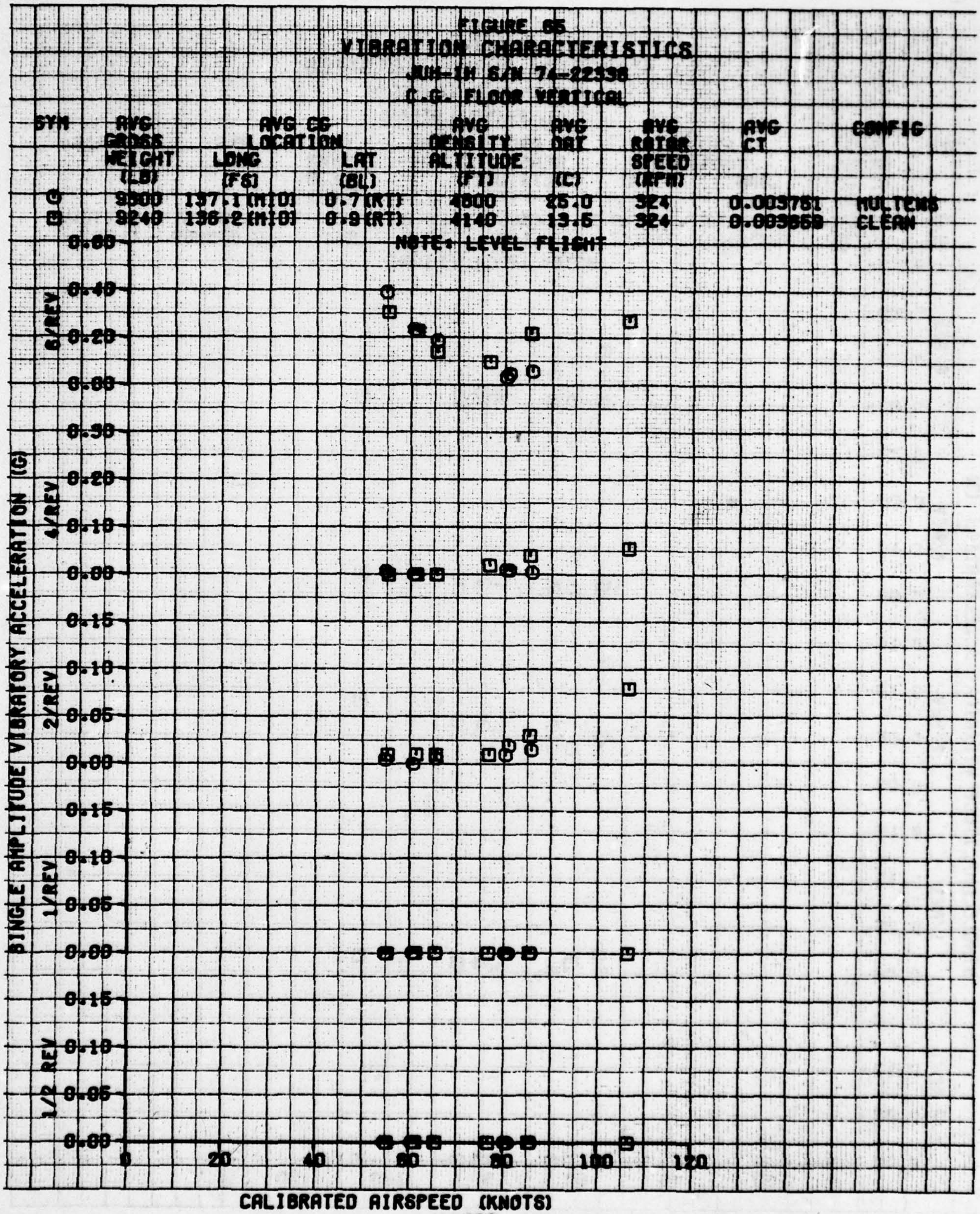
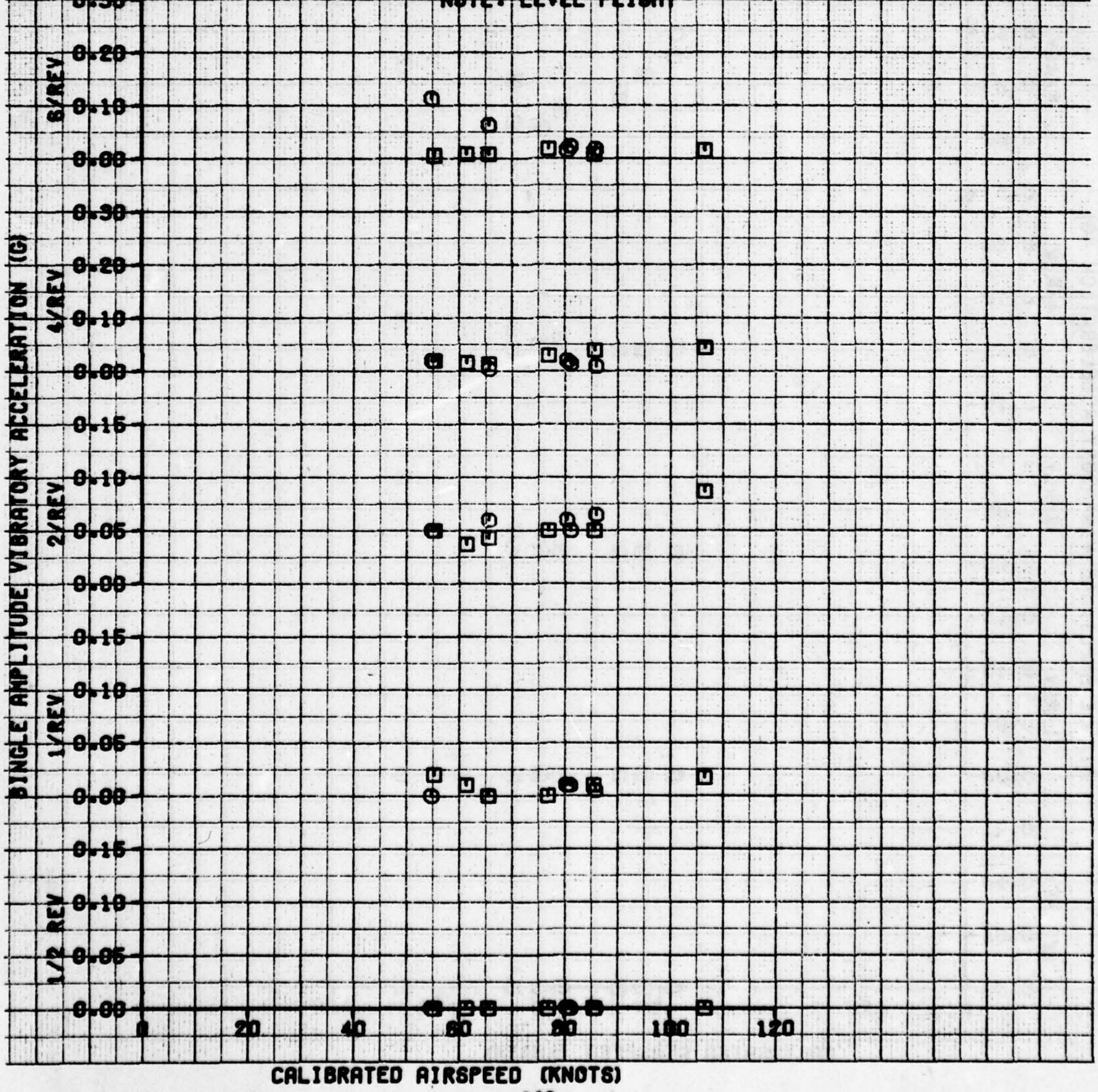


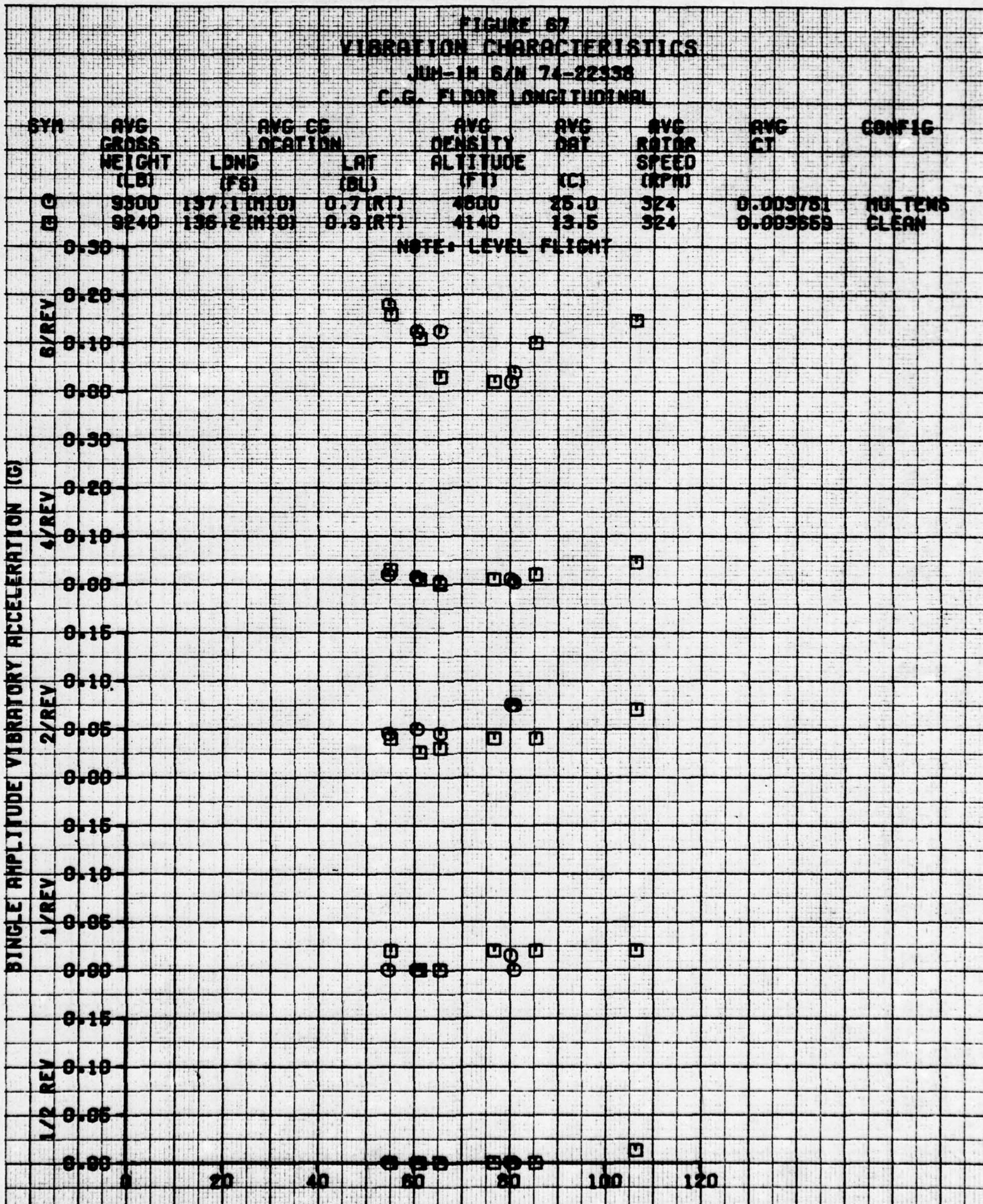
FIGURE 65
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
C.G. FLOOR VERTICAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9300 137.1 (MID) 0.7 (RT) 4800 25.0 324 0.003761 MULTENS
9240 136.2 (MID) 0.9 (RT) 4140 13.5 324 0.003669 CLEAN
NOTE: LEVEL FLIGHT
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.60
0.40
0.20
0.00
0.30
0.20
0.10
0.00
0.15
0.10
0.05
0.00
0.15
0.10
0.05
0.00
0.15
0.10
0.05
0.00
0
20
40
60
80
100
120
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
CALIBRATED AIRSPEED (KNOTS)

FIGURE 66
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
C.G. FLOOR LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIG
⊙	9300	137.1(MID)	0.7(RT)	4800	25.0	324	0.003751	MULTEWS
⊡	9240	136.2(MID)	0.8(RT)	4140	13.5	324	0.003659	CLEAN

NOTE: LEVEL FLIGHT





CALIBRATED AIRSPEED (KNOTS)

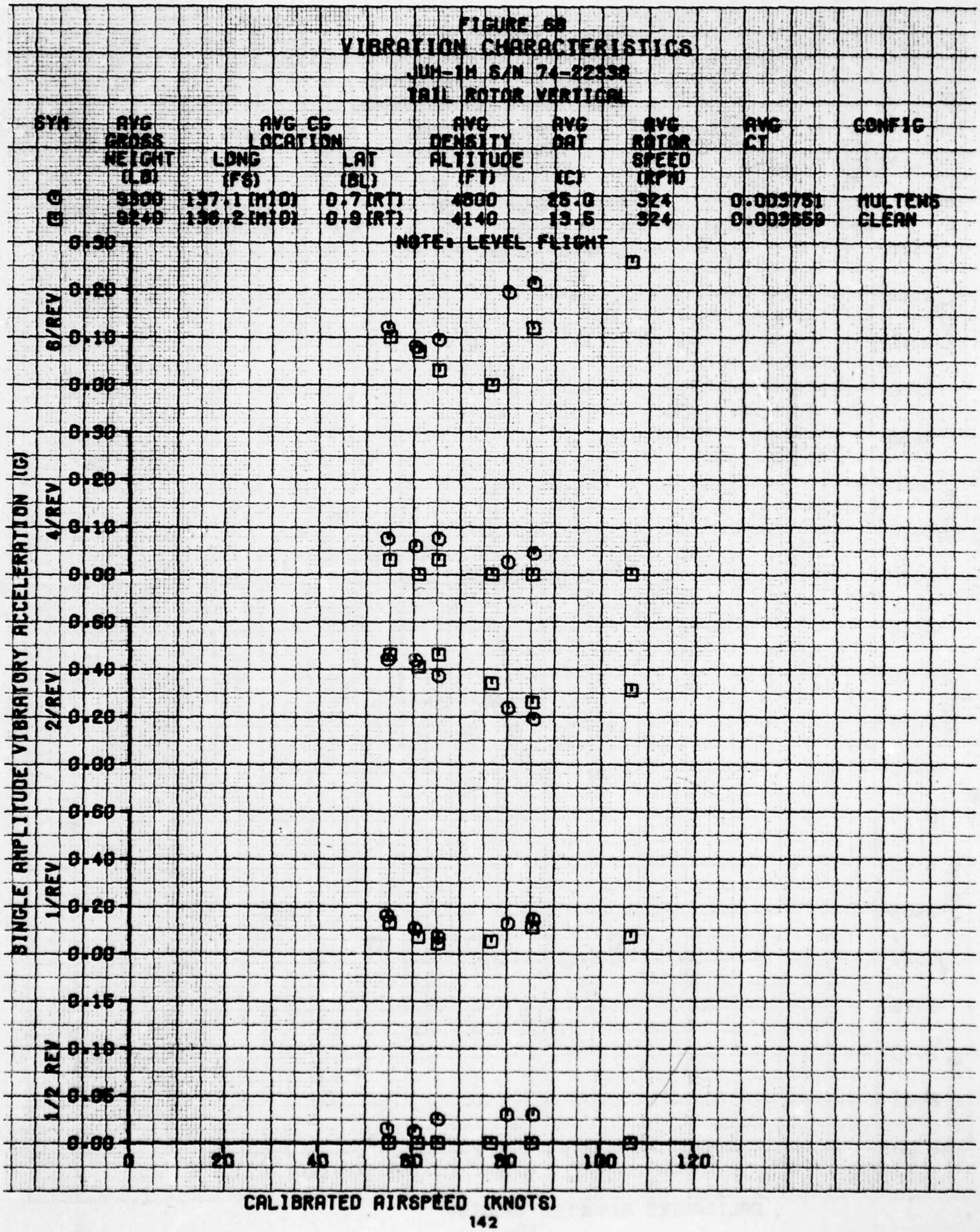
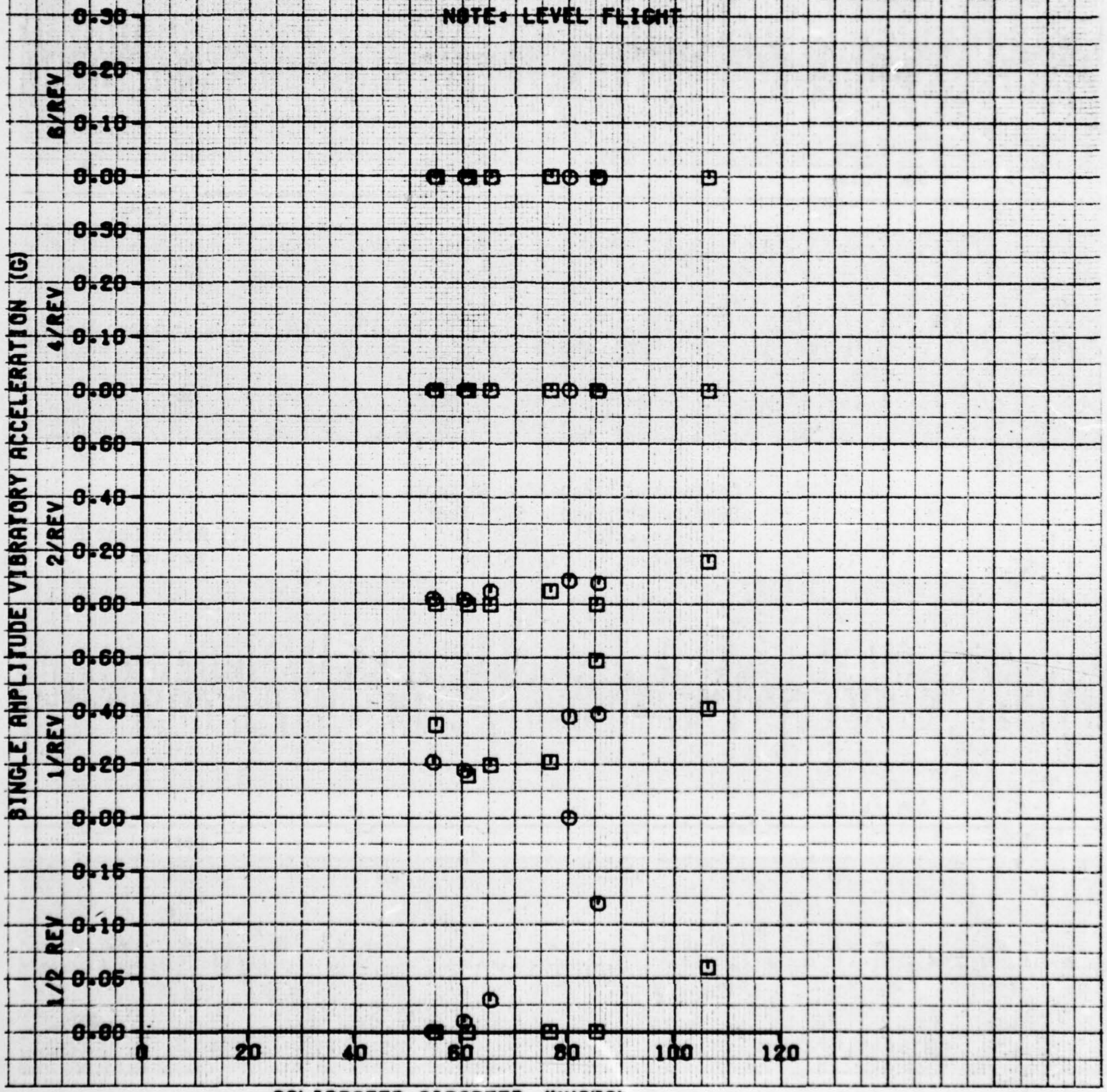


FIGURE 68
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22336
TAIL ROTOR VERTICAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9300 137.1 (MID) 0.7 (RT) 4800 25.0 324 0.003761 MULTENS
9240 136.2 (MID) 0.9 (RT) 4140 13.5 324 0.003559 CLEAN
NOTE: LEVEL FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.60
0.40
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

FIGURE 68
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
TAIL ROTOR LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIG
⊖	9300	137.1 (MID)	0.7 (RT)	4800	25.0	324	0.003751	MULTEWS
⊟	9240	136.2 (MID)	0.9 (RT)	4140	13.5	324	0.003659	CLEAN

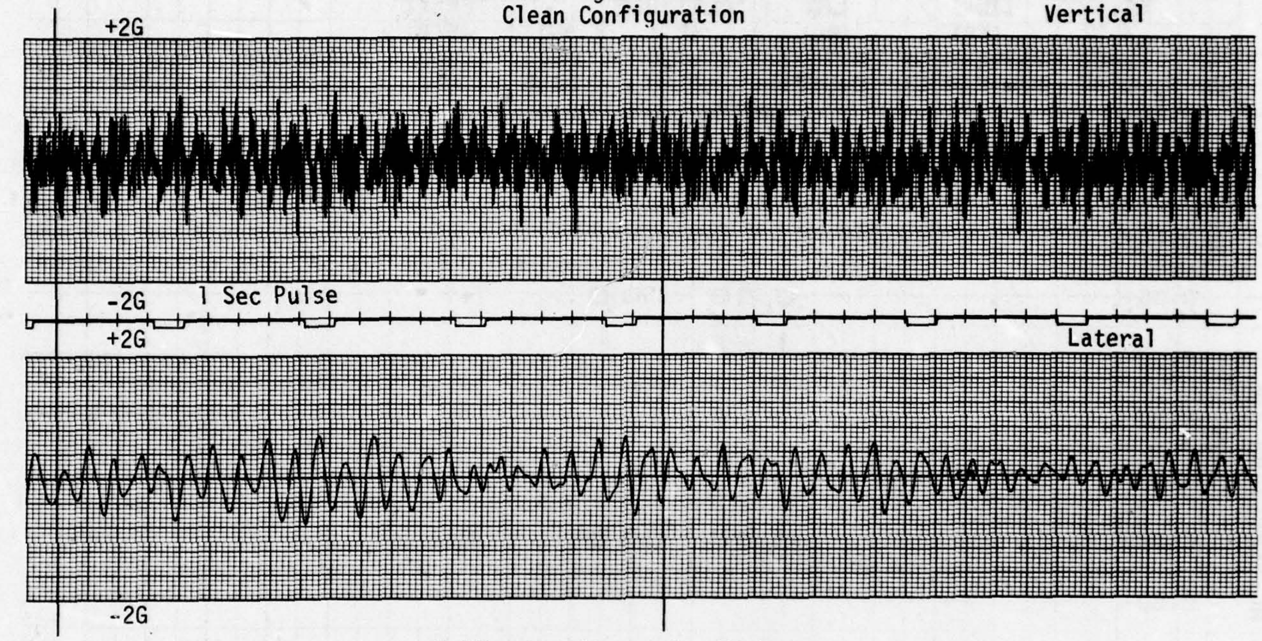
NOTE: LEVEL FLIGHT



CALIBRATED AIRSPEED (KNOTS)

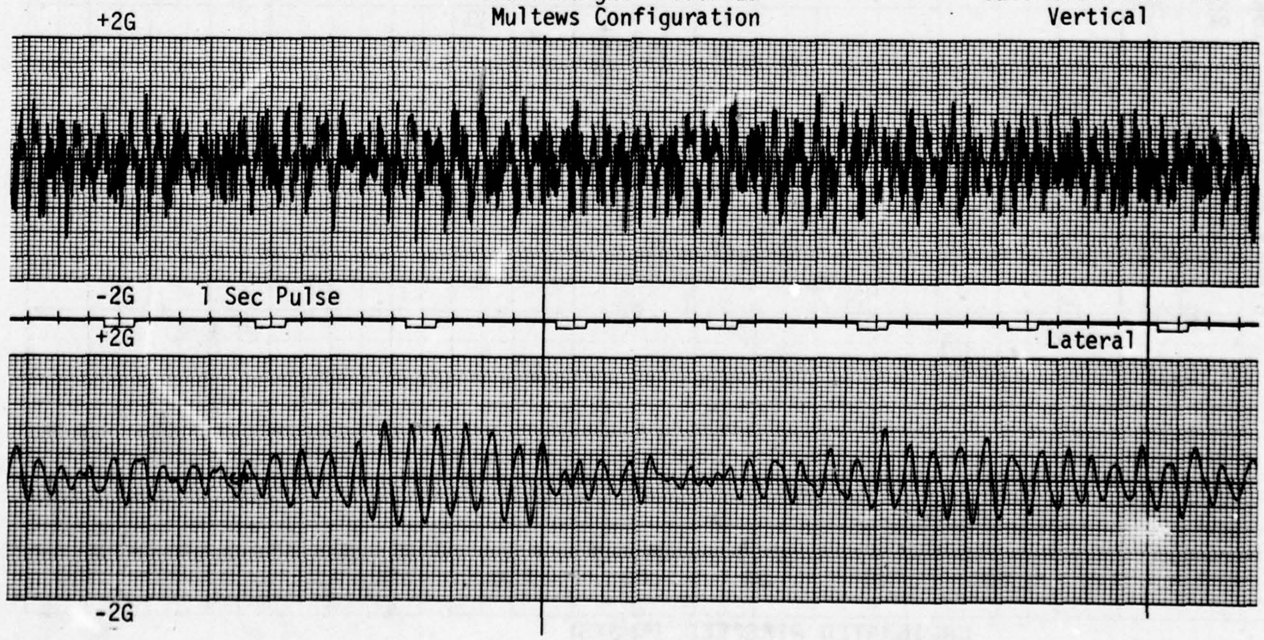
Figure 70
Vibration Characteristics
JUH-1H S/N 74-22338
Mid Center of Gravity
CLIMB
Calibrated Airspeed = 75 Knots
Density Altitude = 3700 Feet
Gross Weight = 9000 LB
Clean Configuration

Tail Rotor Gear Box
Vertical



Calibrated Airspeed - 76 Knots
Density Altitude - 5120 Feet
Gross Weight = 8960 LB
Multews Configuration

Tail Rotor Gear Box
Vertical



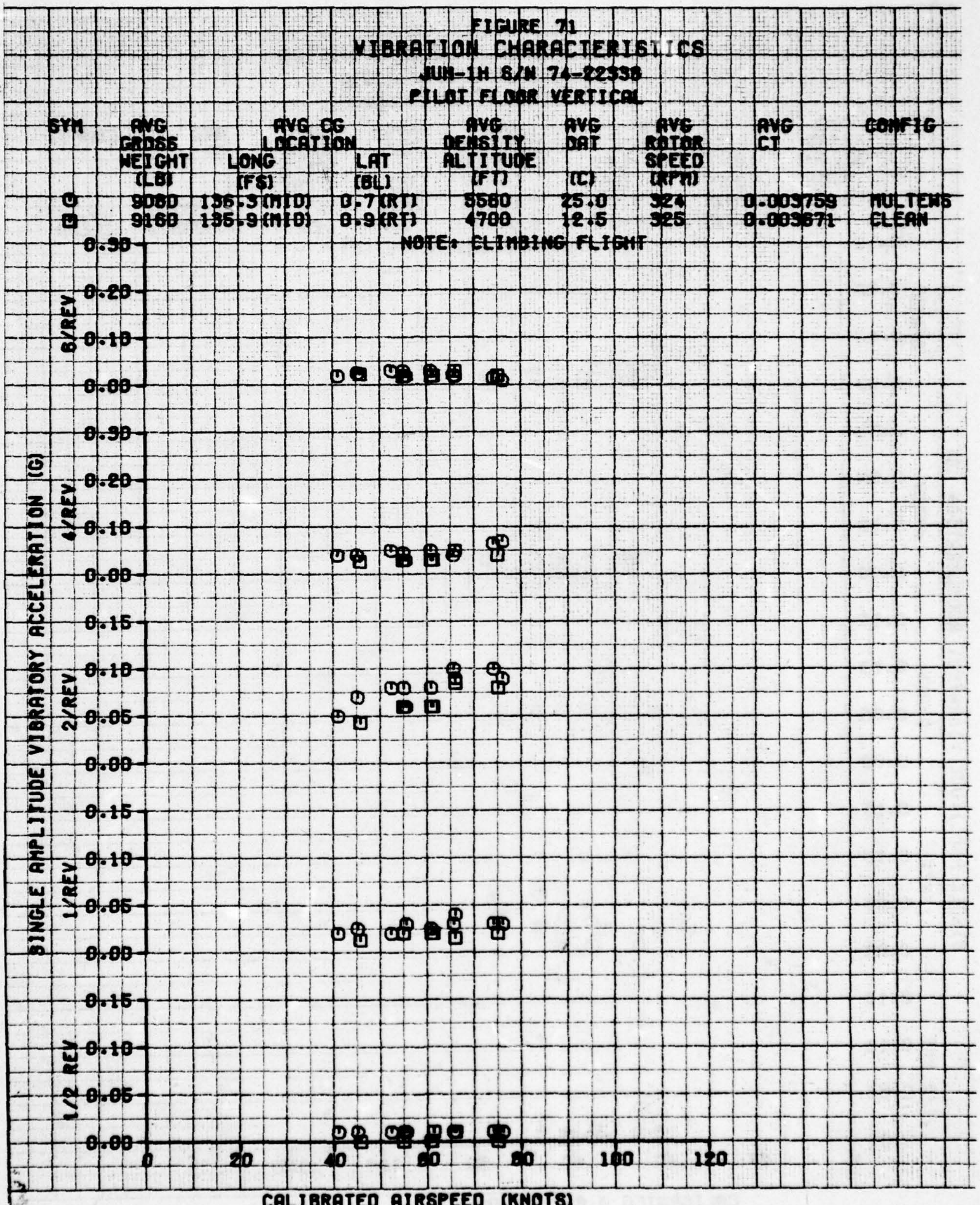


FIGURE 71
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
PILOT FLOOR VERTICAL

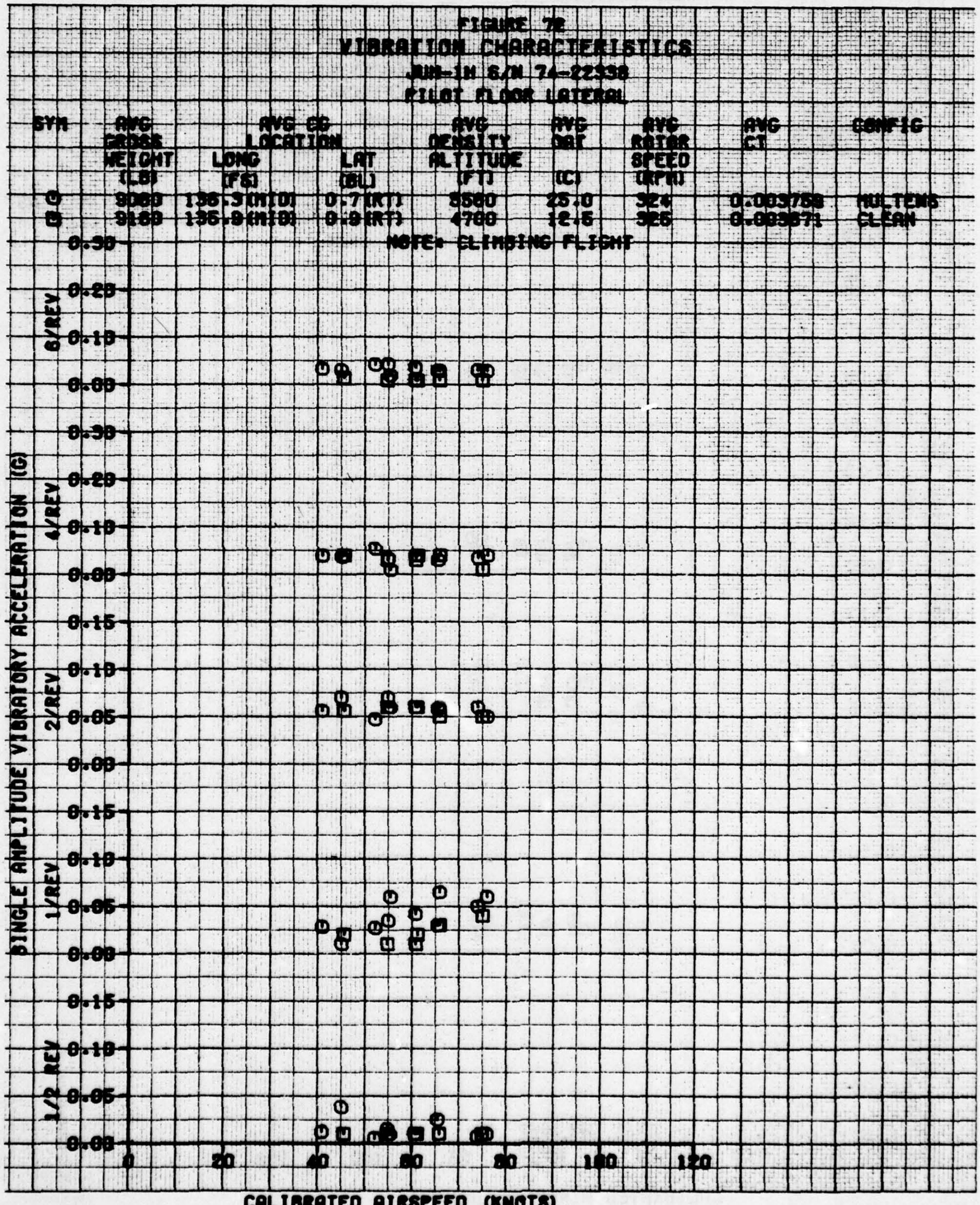
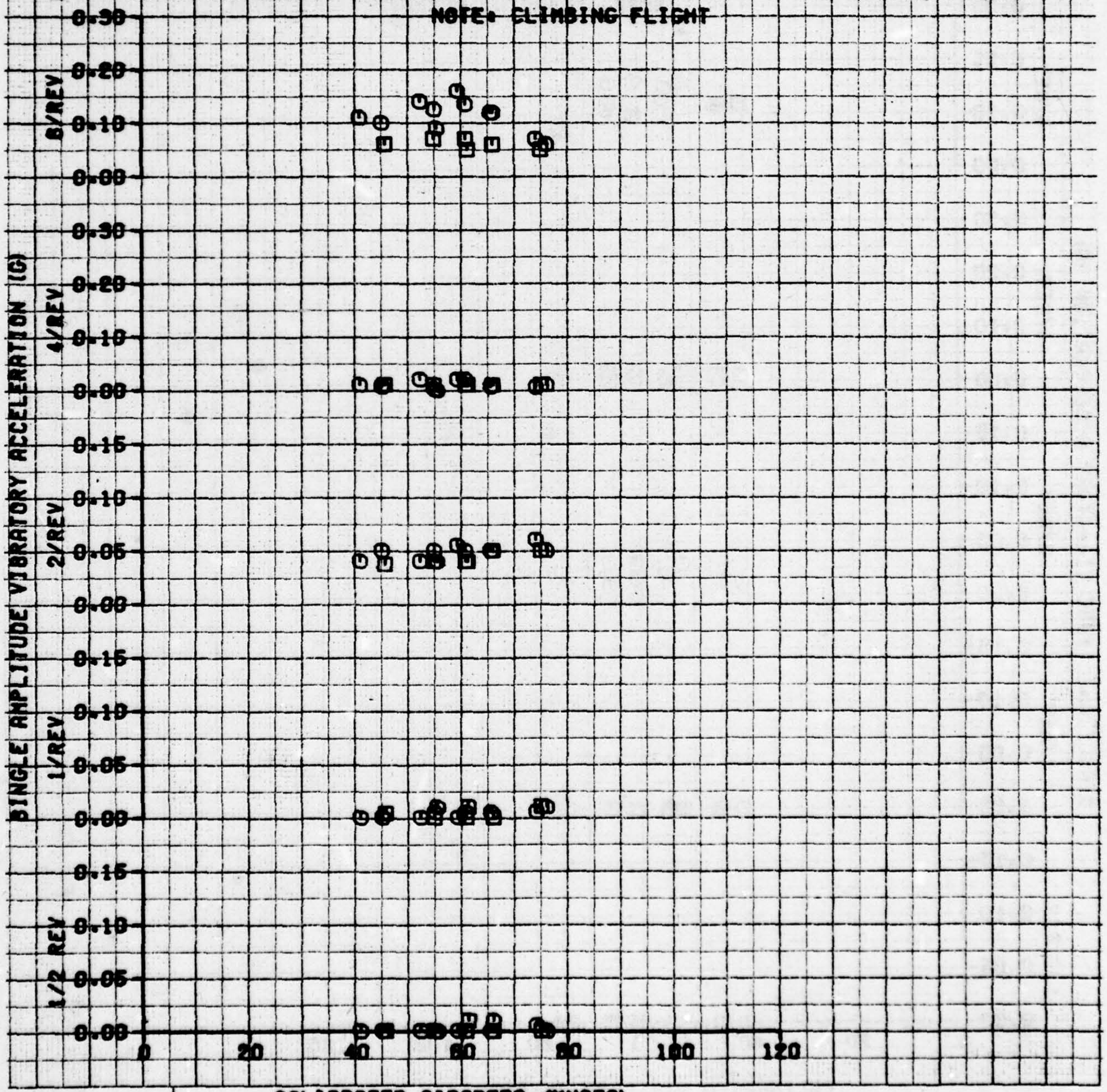


FIGURE 72
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
PILOT FLOOR LATERAL
SYM | AVG GROSS WEIGHT (LB) | AVG CG LOCATION LONG (FS) | LAT (BL) | AVG DENSITY ALTITUDE (FT) | AVG OAT (C) | AVG ROTOR SPEED (RPM) | AVG CT | CONFIG
○ 9080 136.3(MID) 0.7(RT) 5580 25.0 324 0.003759 MULTEMS
□ 9160 135.9(MID) 0.9(RT) 4700 12.5 325 0.003671 CLEAN
NOTE: CLIMBING FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

FIGURE 73
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
PILOT FLOOR LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIG
○	9060	136.3(MID)	0.7(RT)	5560	25.0	324	0.003759	MULTENS
□	9160	135.9(MID)	0.9(RT)	4700	12.5	325	0.003671	CLEAN

NOTE: CLIMBING FLIGHT



CALIBRATED AIRSPEED (KNOTS)

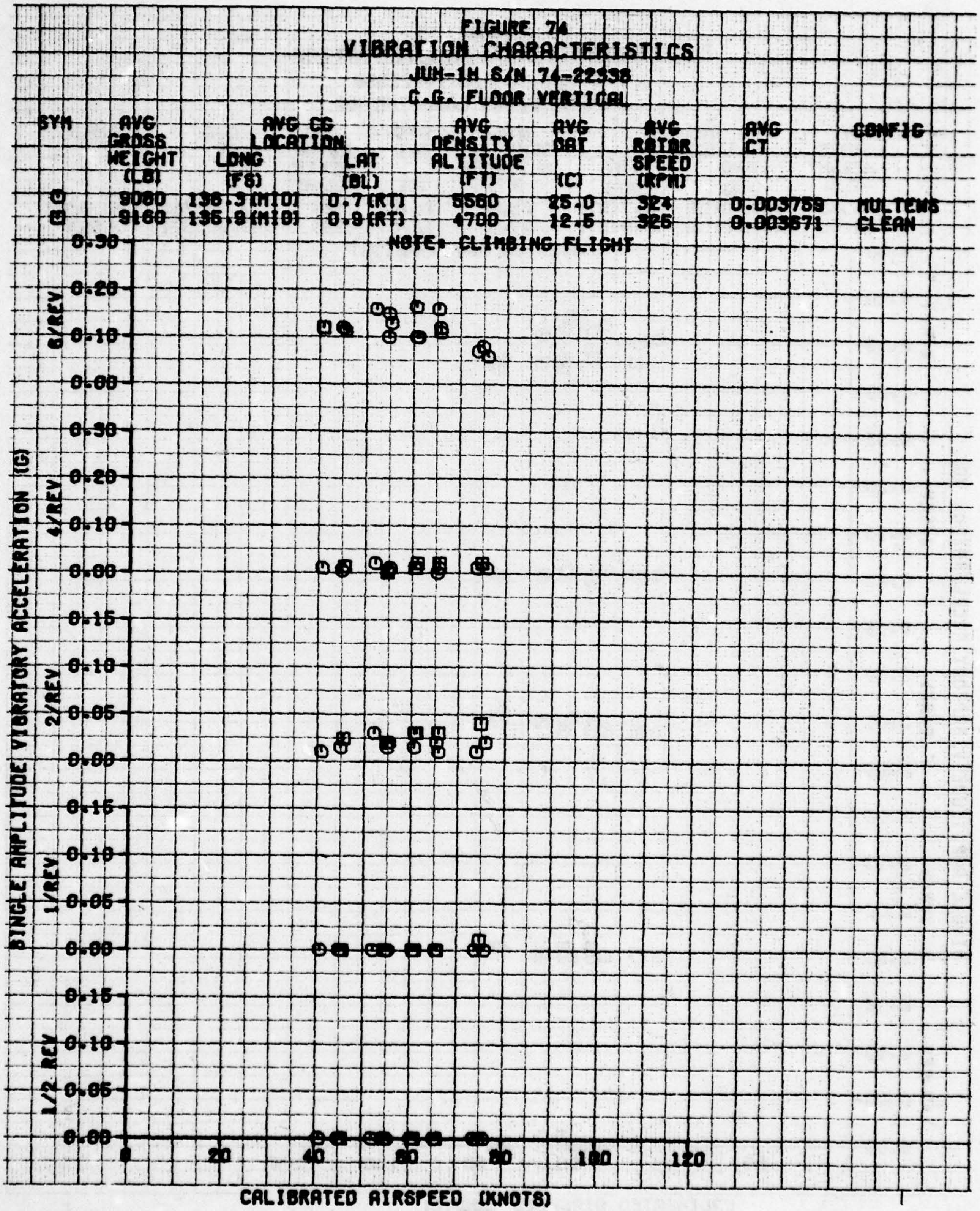


FIGURE 74
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
C.G. FLOOR VERTICAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9080 136.3(MID) 0.7(RT) 5560 25.0 324 0.003759 MULTEMS
9160 135.9(MID) 0.9(RT) 4700 12.5 325 0.003571 CLEAN
NOTE: CLIMBING FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

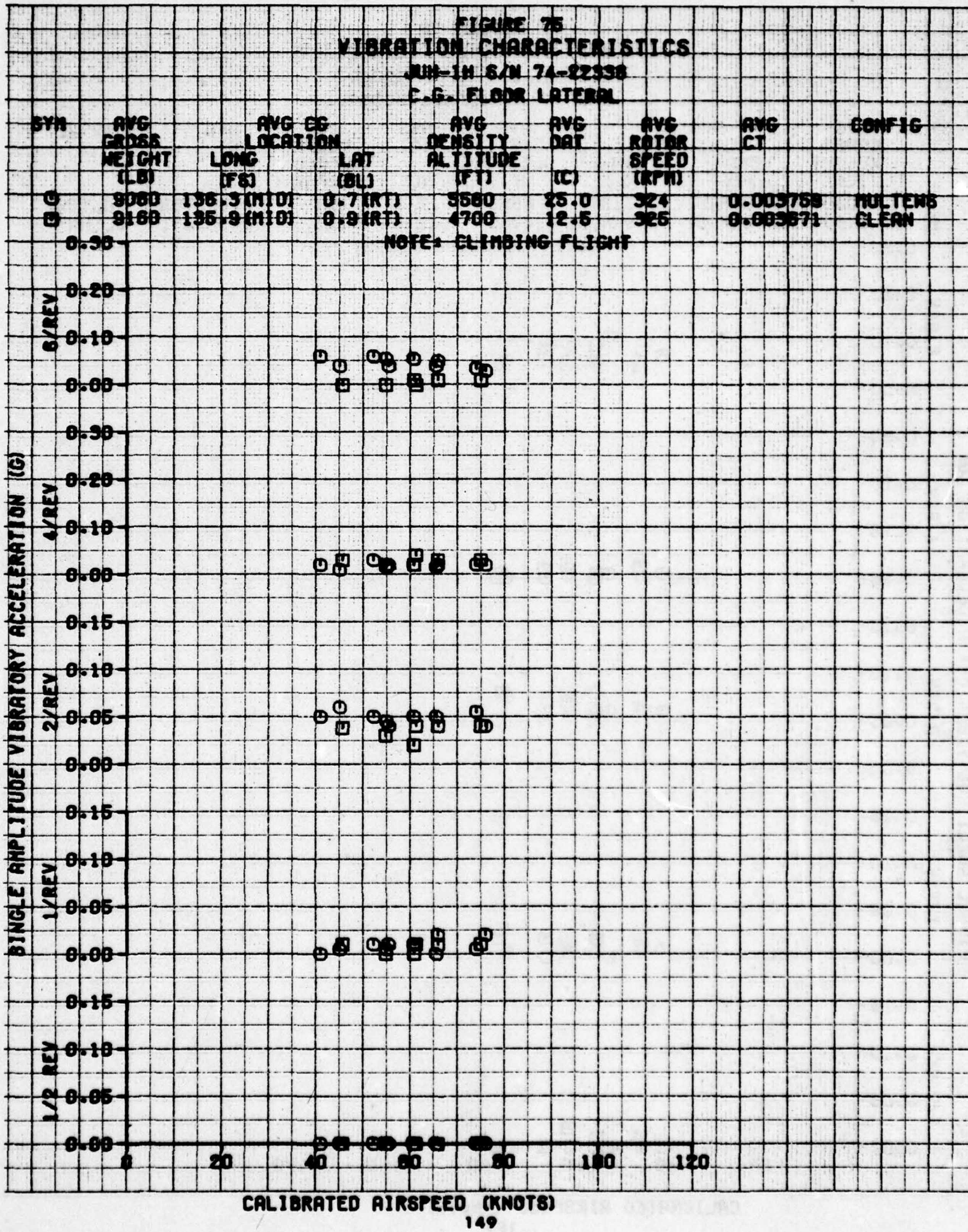


FIGURE 75
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
C.G. FLOOR LATERAL
SYM | AVG GROSS WEIGHT (LB) | AVG CG LOCATION LONG (FS) | LAT (BL) | AVG DENSITY ALTITUDE (FT) | AVG OAT (C) | AVG ROTOR SPEED (RPM) | AVG CT | CONFIG
○ 9080 | 136.3(MID) | 0.7(RT) | 5580 | 25.0 | 324 | 0.003758 | MULTENG
□ 9160 | 135.9(MID) | 0.9(RT) | 4700 | 12.5 | 325 | 0.003671 | CLEAN
NOTE: CLIMBING FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

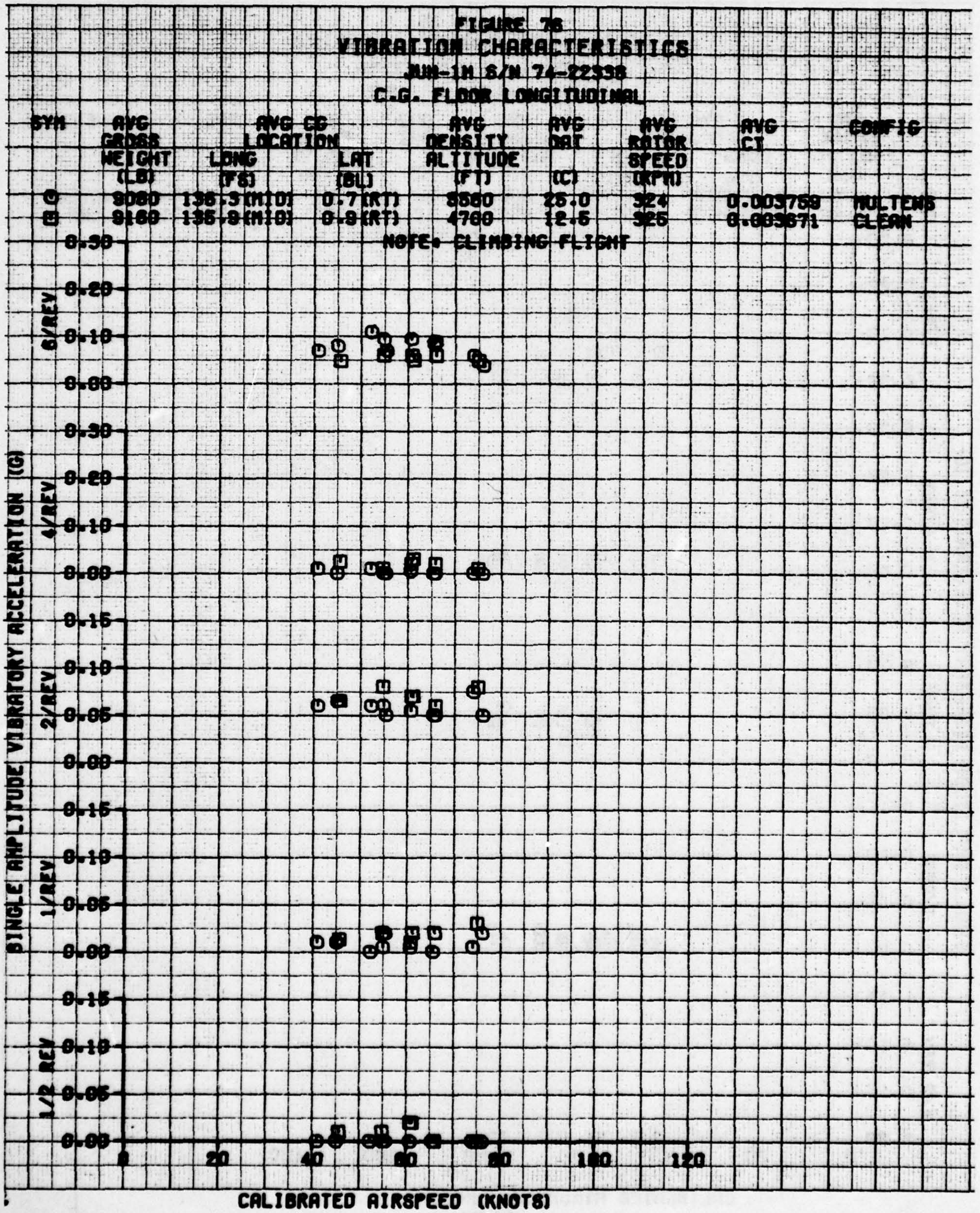
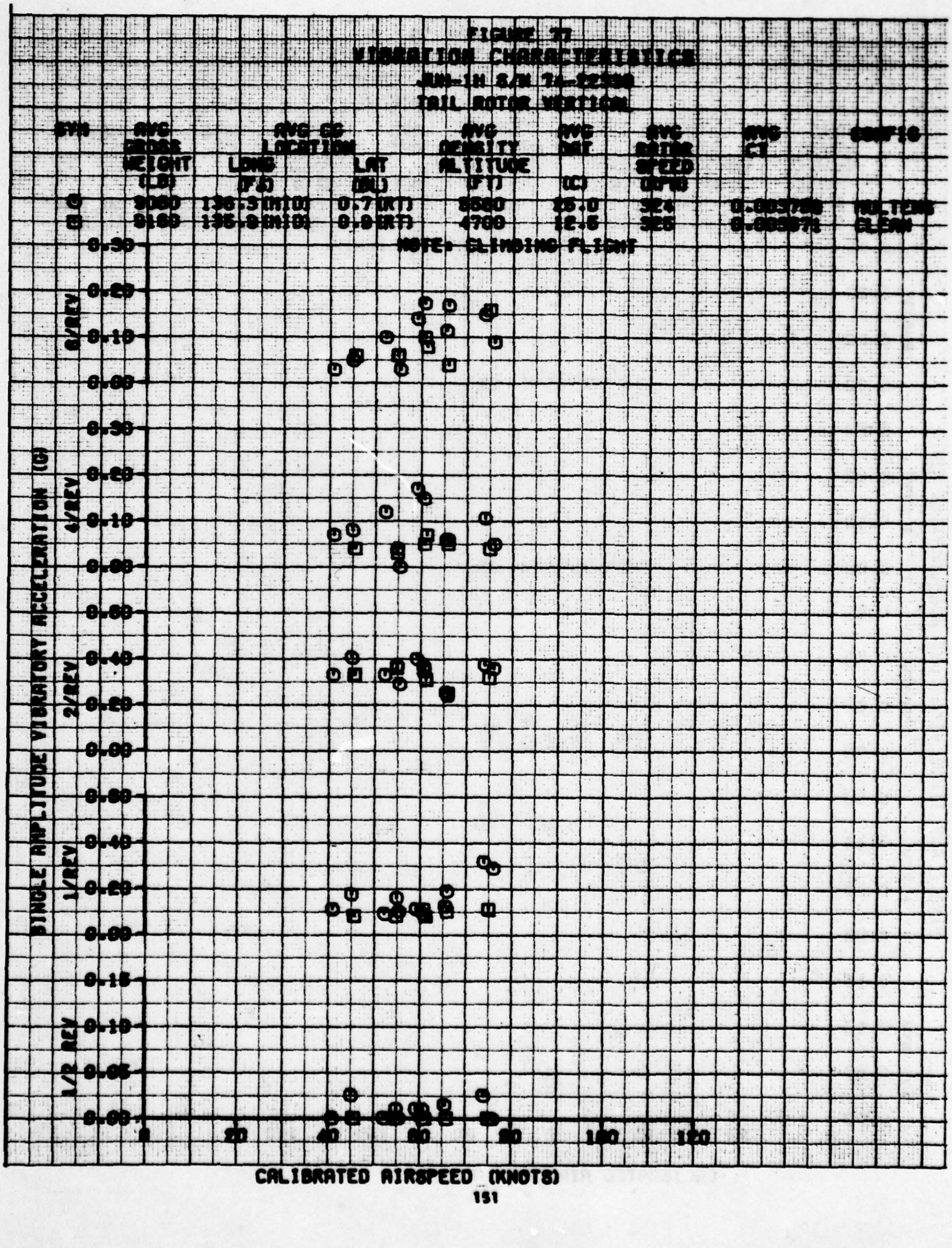


FIGURE 76
VIBRATION CHARACTERISTICS
JUH-1M S/N 74-22338
C.G. FLOOR LONGITUDINAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
8080 136.3(MID) 0.7(RT) 5580 25.0 324 0.003759 MULTENS
8160 136.8(MID) 0.8(RT) 4700 12.5 325 0.003671 CLEAN
NOTE: CLIMBING FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)


VIBRATION CHARACTERISTICS
TAIL ROTOR VERTICAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG
LAT
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
NOTE: CLIMBING FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

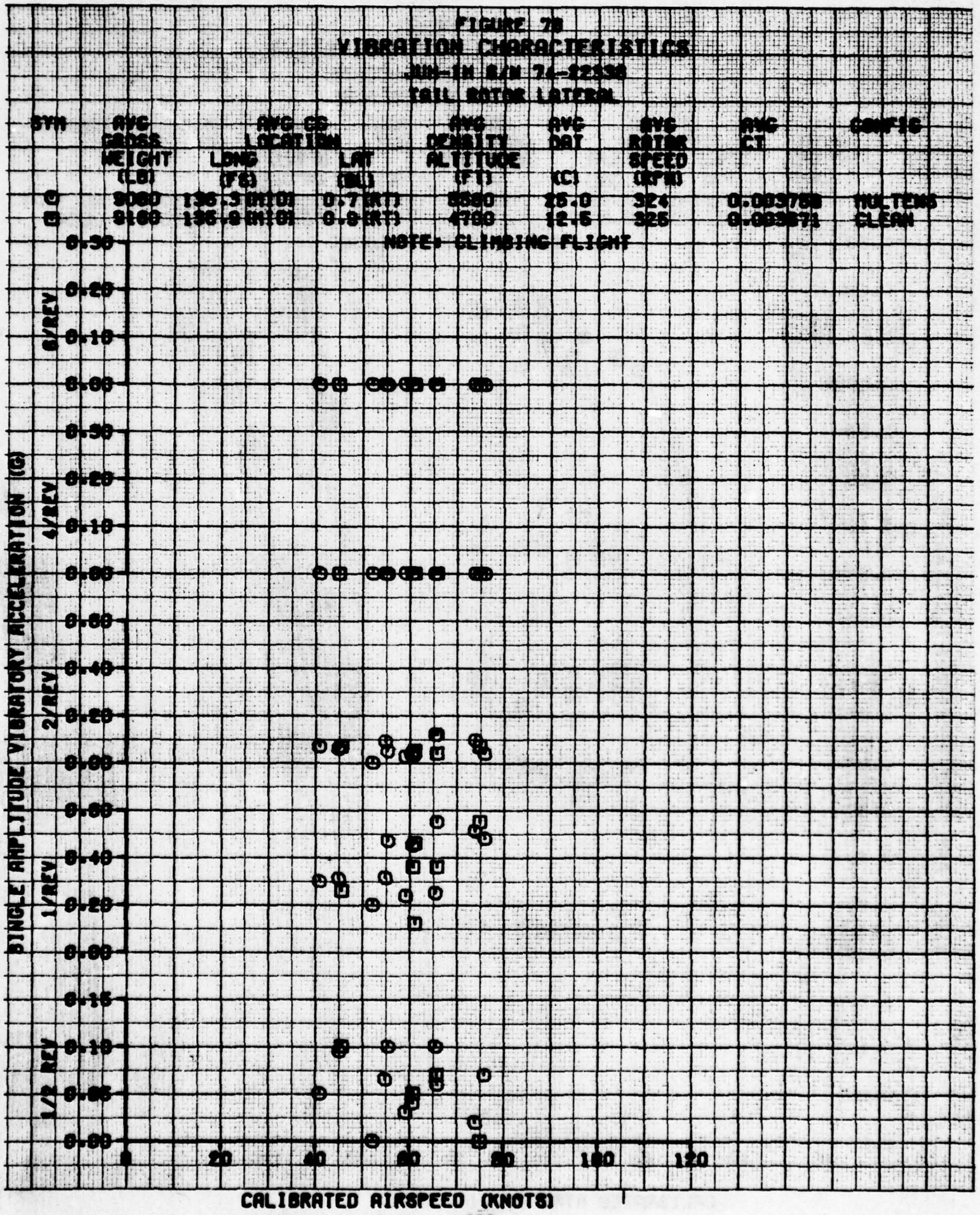
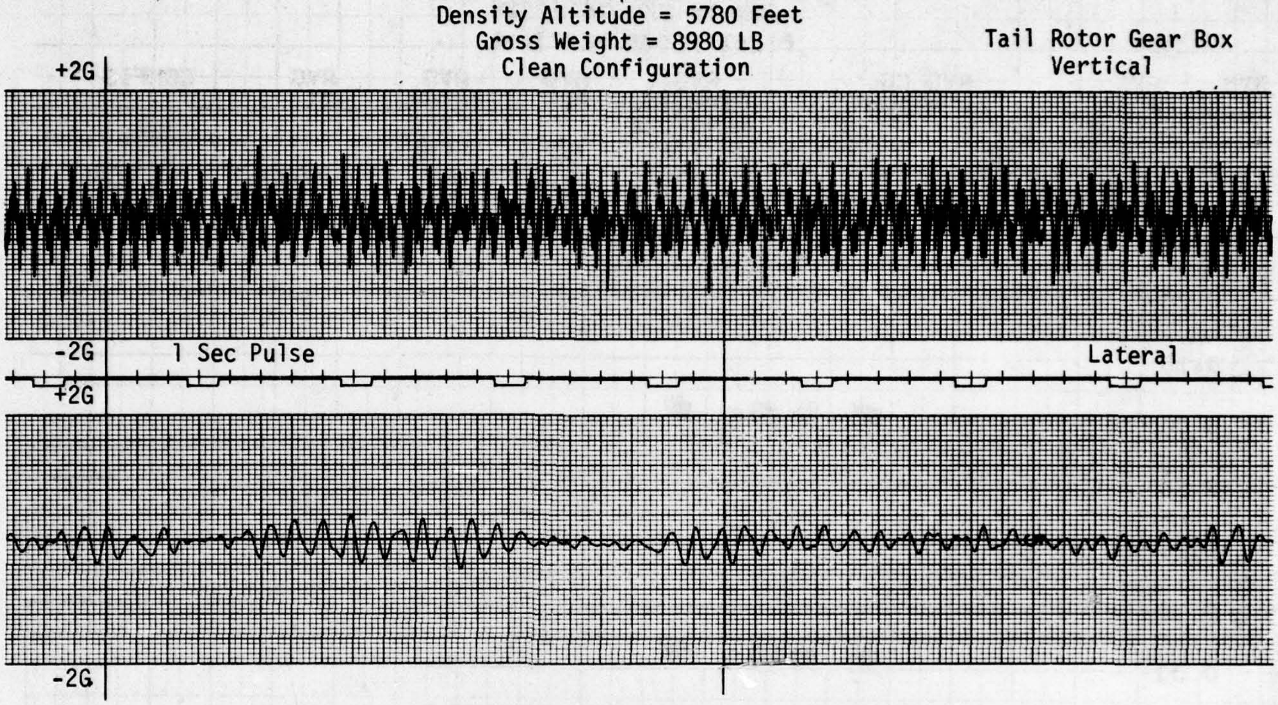
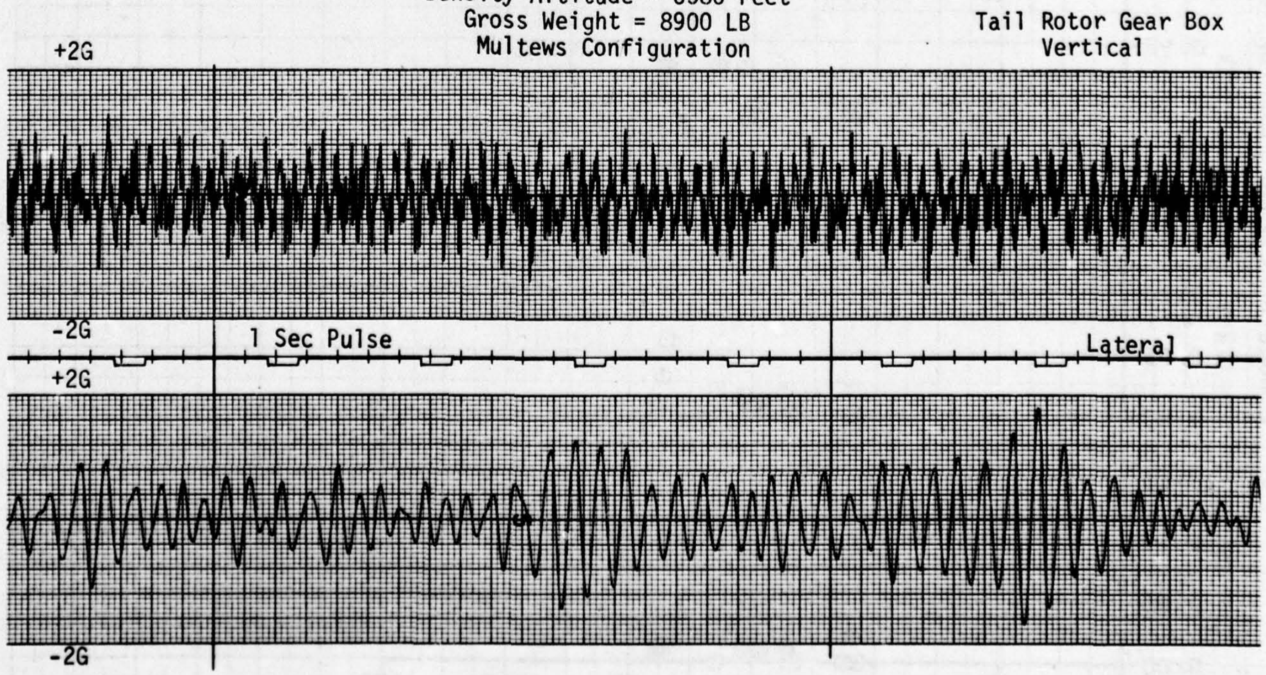

VIBRATION CHARACTERISTICS
TAIL ROTOR LATERAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
CLEAN
NOTE: CLIMBING FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
1/2 REV
1/REV
2/REV
4/REV
6/REV
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

Figure 79
Vibration Characteristics
Mid Center of Gravity
Autorotation
Calibrated Airspeed = 76 Knots
Density Altitude = 5780 Feet
Gross Weight = 8980 LB
Clean Configuration



Calibrated Airspeed = 75 Knots
Density Altitude = 6580 Feet
Gross Weight = 8900 LB
Multews Configuration



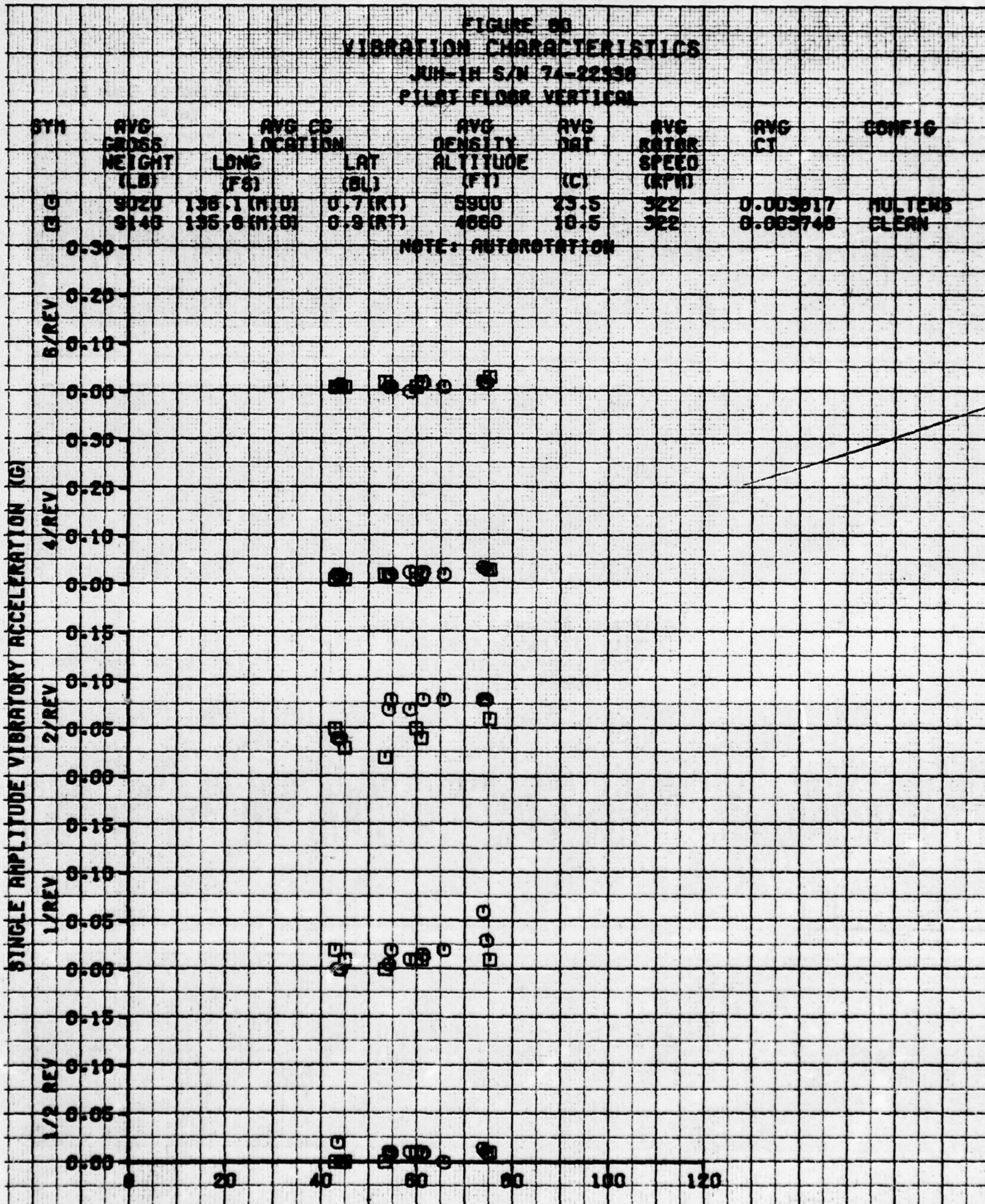


FIGURE 80
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
PILOT FLOOR VERTICAL
SYM | AVG GROSS WEIGHT (LB) | AVG CG LOCATION LONG (FS) | LAT (BL) | AVG DENSITY ALTITUDE (FT) | AVG OAT (C) | AVG ROTOR SPEED (RPM) | AVG CT | CONFIG
9020 | 136.1(MID) | 0.7(RT) | 5900 | 23.5 | 322 | 0.003917 | MULTENS
9140 | 135.8(MID) | 0.9(RT) | 4660 | 18.5 | 322 | 0.003748 | CLEAN
NOTE: AUTOROTATION
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
CALIBRATED AIRSPEED (KNOTS)

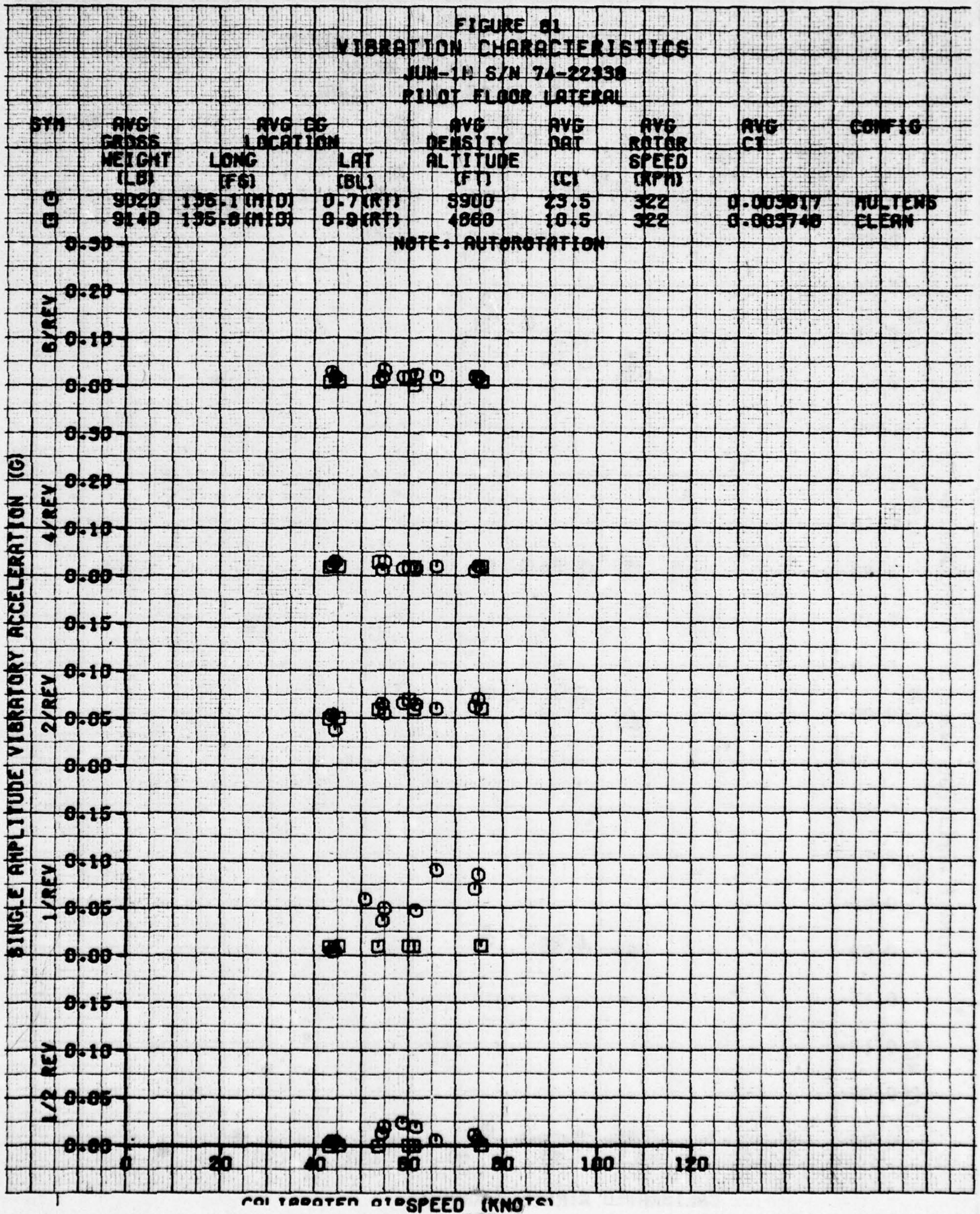


FIGURE 81
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
PILOT FLOOR LATERAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9020 136.1(MID) 0.7(RT) 5900 23.5 322 0.003817 MULTENS
9140 135.8(MID) 0.9(RT) 4660 18.5 322 0.003748 CLEAN
NOTE: AUTOROTATION
6/REV
4/REV
2/REV
1/REV
1/2 REV
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
0.30
0.20
0.10
0.00
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

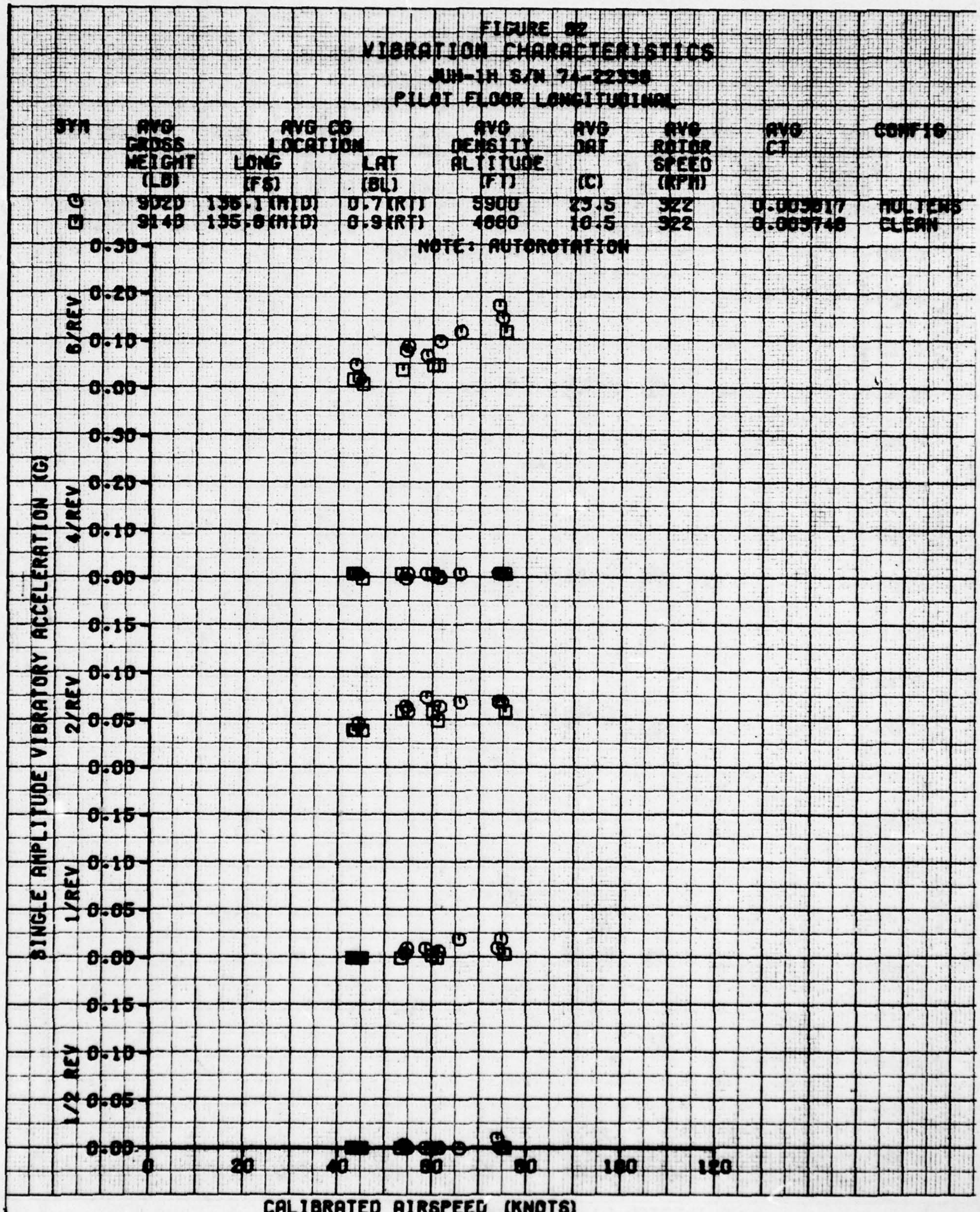


FIGURE 82
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
PILOT FLOOR LONGITUDINAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9020 136.1(MID) 0.7(RT) 5900 23.5 322 0.003817 MULTENS
9140 135.8(MID) 0.9(RT) 4860 10.5 322 0.003748 CLEAN
NOTE: AUTOROTATION
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

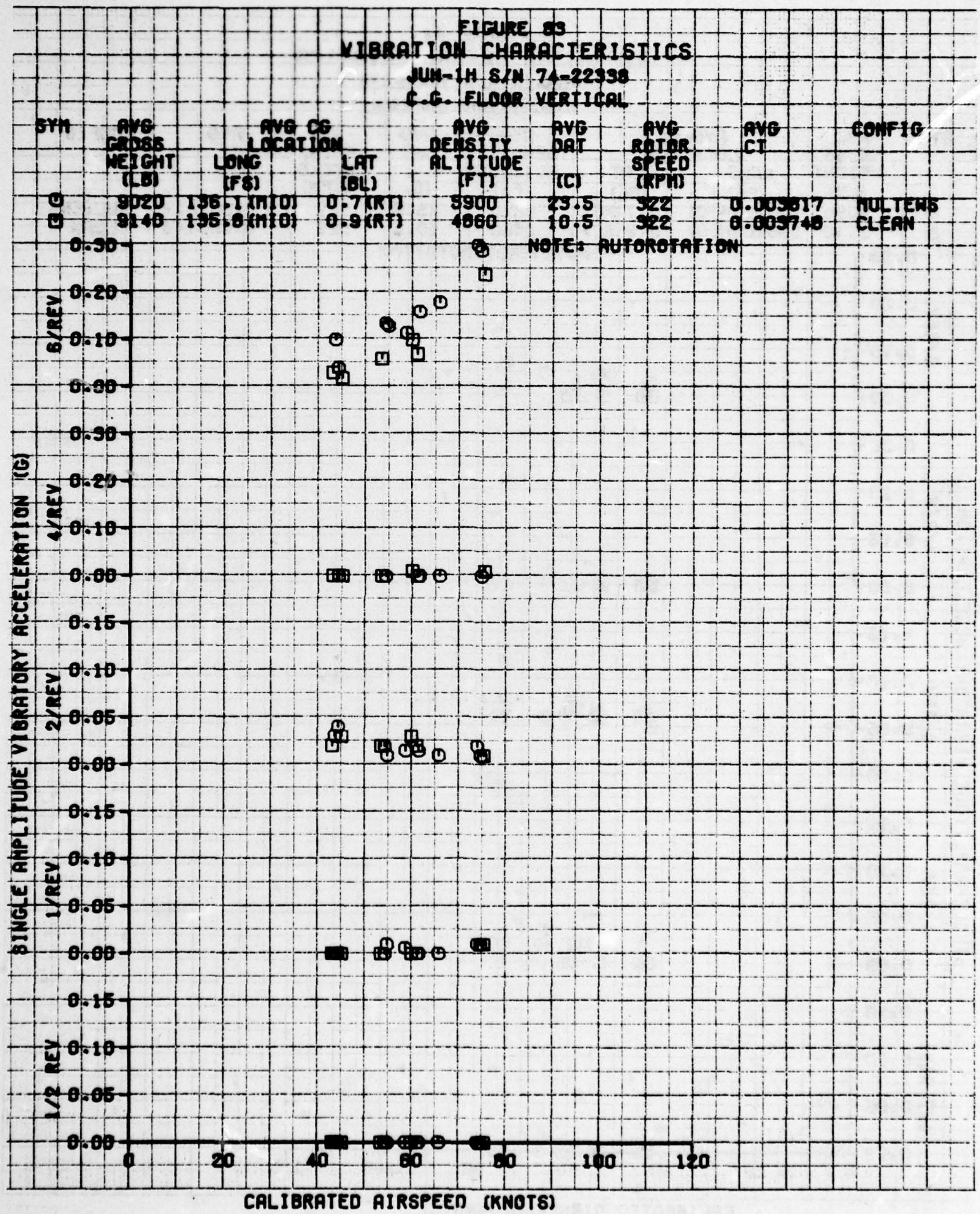


FIGURE 83
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
C.G. FLOOR VERTICAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9020 136.1(MID) 0.7(RT) 5900 23.5 322 0.003817 MULTEWS
9140 135.8(MID) 0.9(RT) 4860 10.5 322 0.003748 CLEAN
NOTE: AUTOROTATION
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.15
0.10
0.05
0.00
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

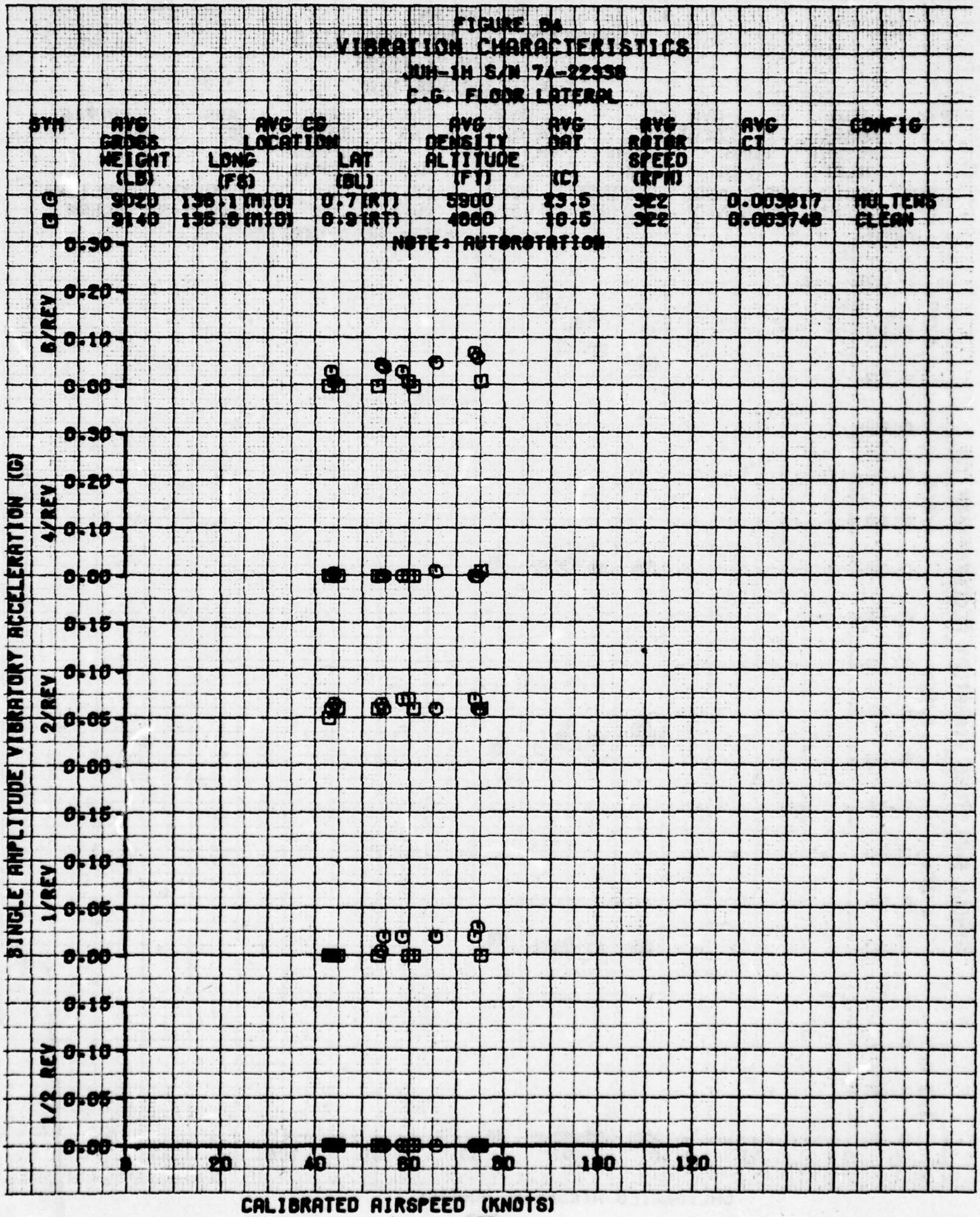
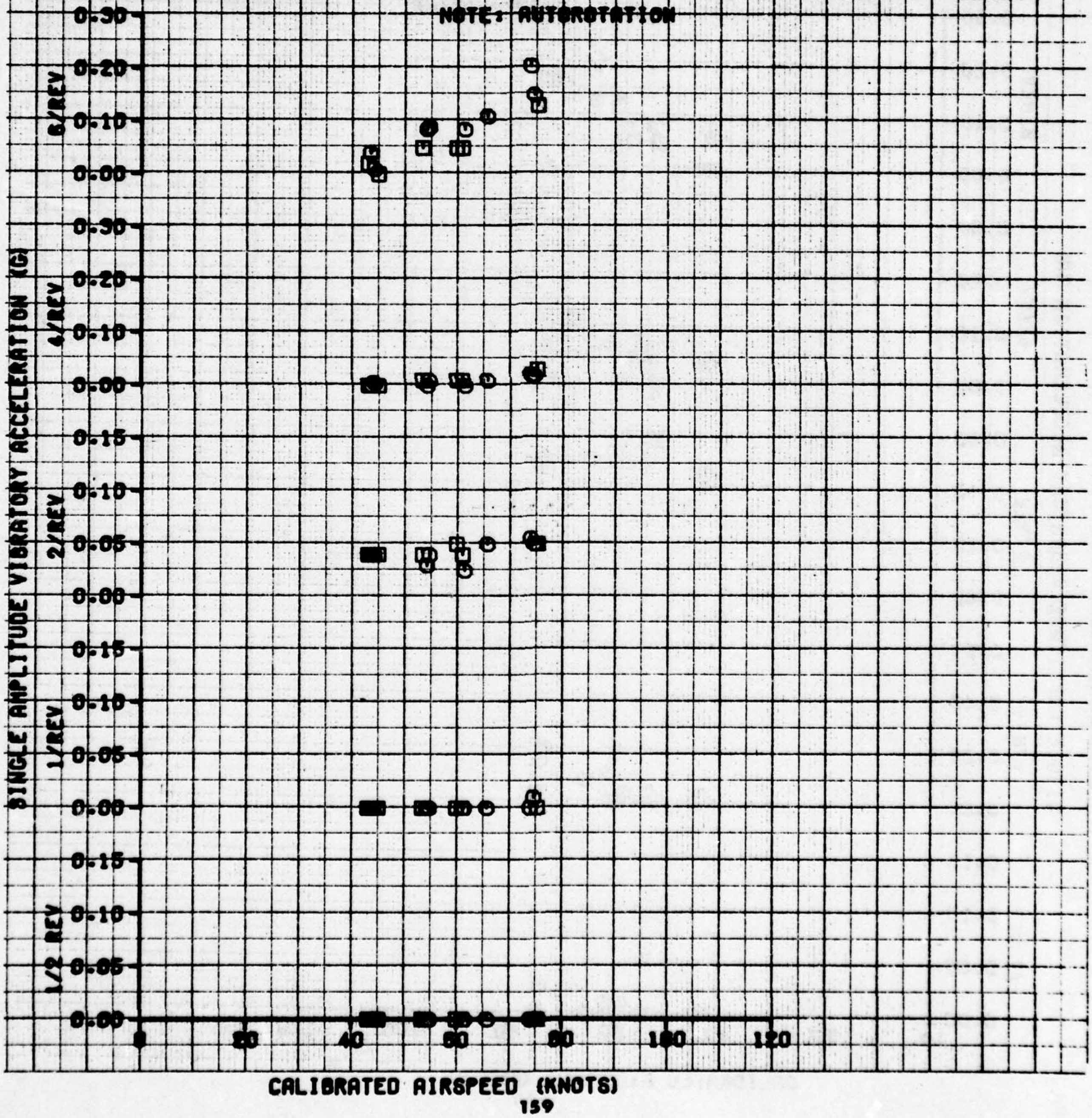


FIGURE 96
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
C.G. FLOOR LATERAL
SYM | AVG GROSS WEIGHT (LB) | AVG CG LOCATION LONG (FS) | LAT (BL) | AVG DENSITY ALTITUDE (FT) | AVG OAT (C) | AVG ROTOR SPEED (RPM) | AVG CT | CONFIG
9020 | 136.1 (MID) | 0.7 (RT) | 5900 | 23.5 | 322 | 0.003817 | MULTENS
9140 | 135.8 (MID) | 0.9 (RT) | 4880 | 18.5 | 322 | 0.003748 | CLEAN
NOTE: AUTOROTATION
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

FIGURE 85
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
C.G. FLOOR LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIG
⊙	9020	136.1(MID)	0.7(RT)	5900	23.5	322	0.003917	MULTENS
⊡	9140	135.8(MID)	0.9(RT)	4060	18.5	322	0.003748	CLEAN

NOTE: AUTOROTATION



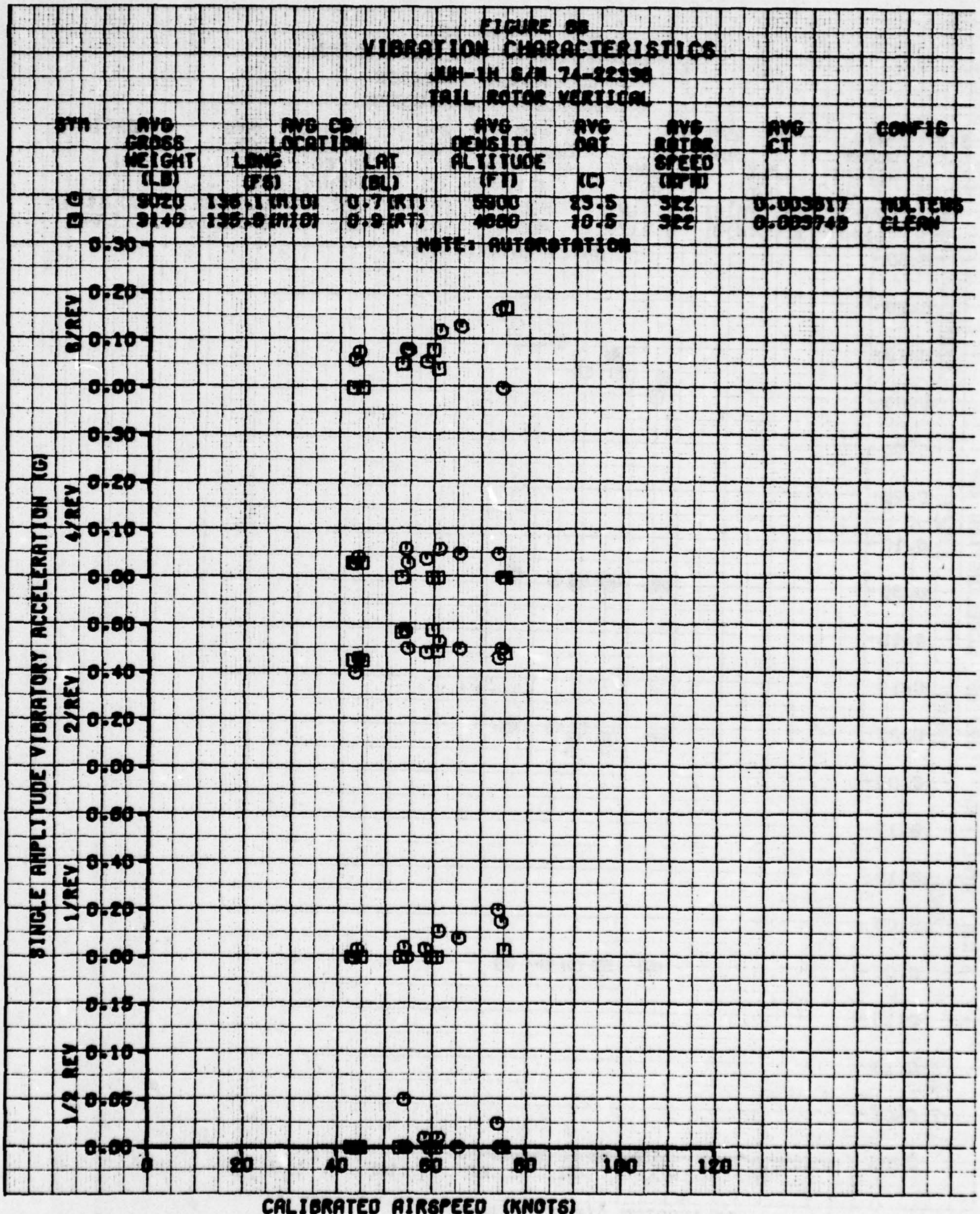


FIGURE 88
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22330
TAIL ROTOR VERTICAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9020 136.1(MID) 0.7(RT) 5900 23.5 322 0.003817 MULTEMS
9140 135.9(MID) 0.9(RT) 4000 18.5 322 0.003748 CLEAN
NOTE: AUTOROTATION
SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)
8/REV
4/REV
2/REV
1/REV
1/2 REV
CALIBRATED AIRSPEED (KNOTS)

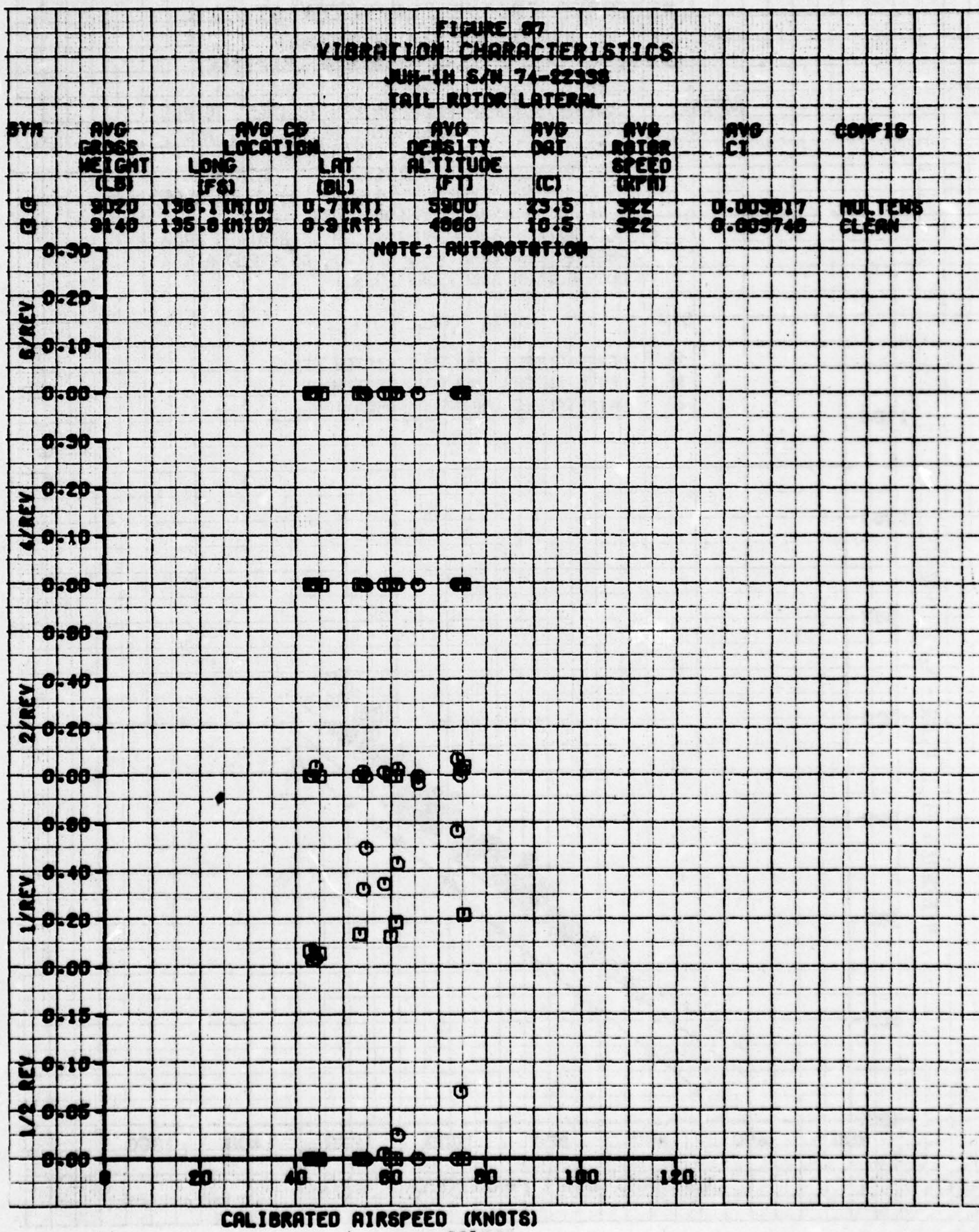


FIGURE 87
VIBRATION CHARACTERISTICS
JUH-1H S/N 74-22338
TAIL ROTOR LATERAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIG
9020 136.1(MID) 0.7(RT) 5900 23.5 322 0.003817 MULTEWS
9140 135.8(MID) 0.9(RT) 4880 10.5 322 0.003748 CLEAN
NOTE: AUTOROTATION
6/REV
4/REV
2/REV
1/REV
1/2 REV
0.30
0.20
0.10
0.00
0.60
0.40
0.15
0.05
0
20
40
60
80
100
120
CALIBRATED AIRSPEED (KNOTS)

FIGURE 88

REFERRED ENGINE CHARACTERISTICS

JUH-1H USA S/N 74-22358

LYCOMING ENGINE T53-L-13B S/N LE12924X

NOTES:
1. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 7 , APP A).
2. DATA OBTAINED IN LEVEL FLIGHT.
3. LONG DASHED LINE - MULTEWS OFF - OBTAINED FROM ENGINE SPEC (REF 8 , APP A), 1.05% BLEED AIR LOSS, 8.4SHP ACCESSORY LOSS.
4. DOT-DASHED LINE - MULTEWS ON - OBTAINED FROM ENGINE SPEC (REF 8 , APP A), 4% BLEED AIR LOSS, 8.4SHP ACCESSORY LOSS.

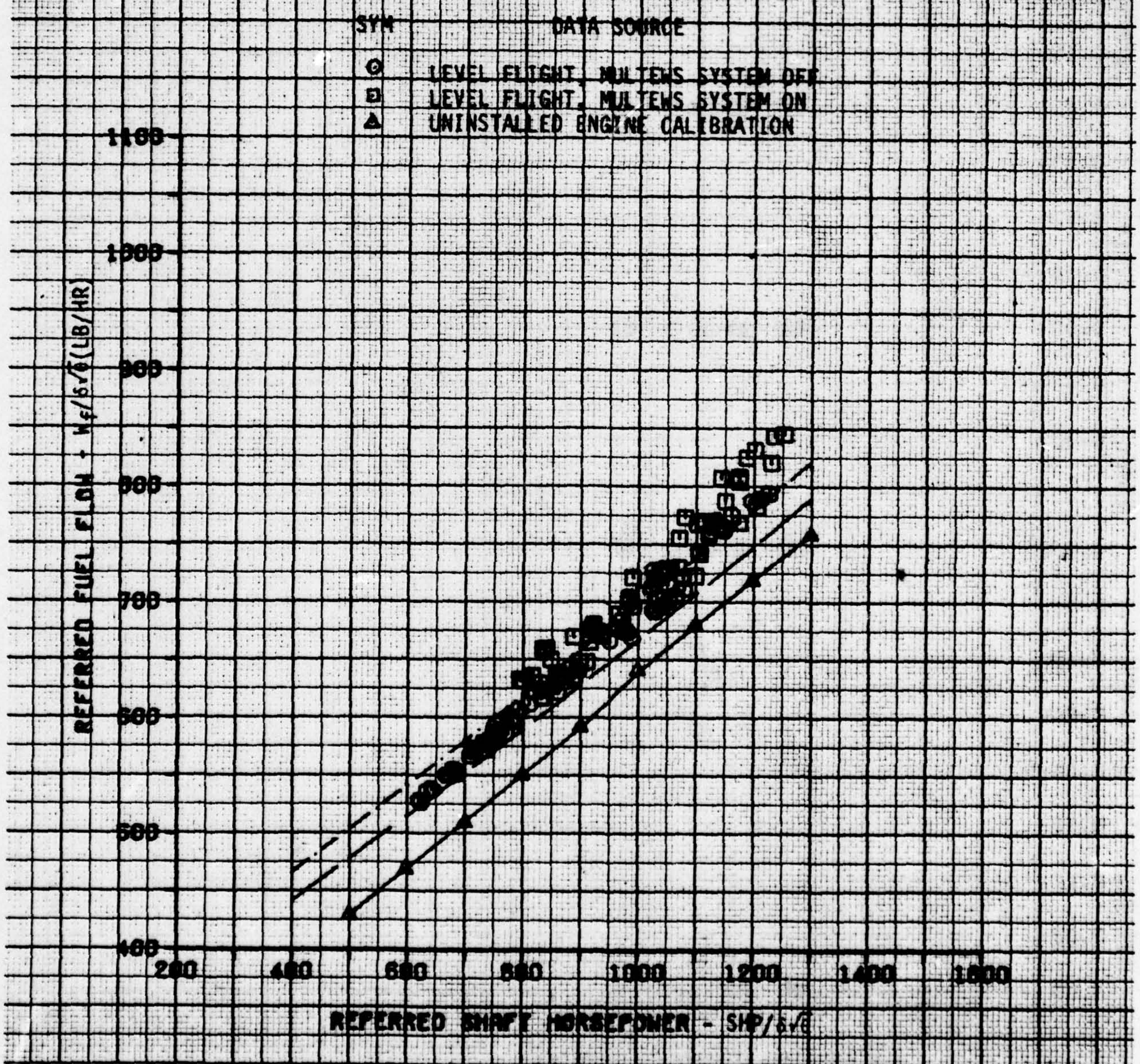


FIGURE 89

REFERRED ENGINE CHARACTERISTICS

JUH-1H USA S/N 74-22356

LYCOMING ENGINE T53-L-13B S/N LE12924X

NOTES:
1. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 7, APP A).
2. DATA OBTAINED IN LEVEL FLIGHT.
3. LONG DASHED LINE - MULTEWS OFF - OBTAINED FROM ENGINE SPEC (REF 8, APP A), 1.15% BLEED AIR LOSS & 4 SHP ACCESSORY LOSS.
4. DOT-DASHED LINE - MULTEWS ON - OBTAINED FROM ENGINE SPEC (REF 8, APP (A), 4% BLEED AIR LOSS 8.4 SHP ACCESSORY LOSS.

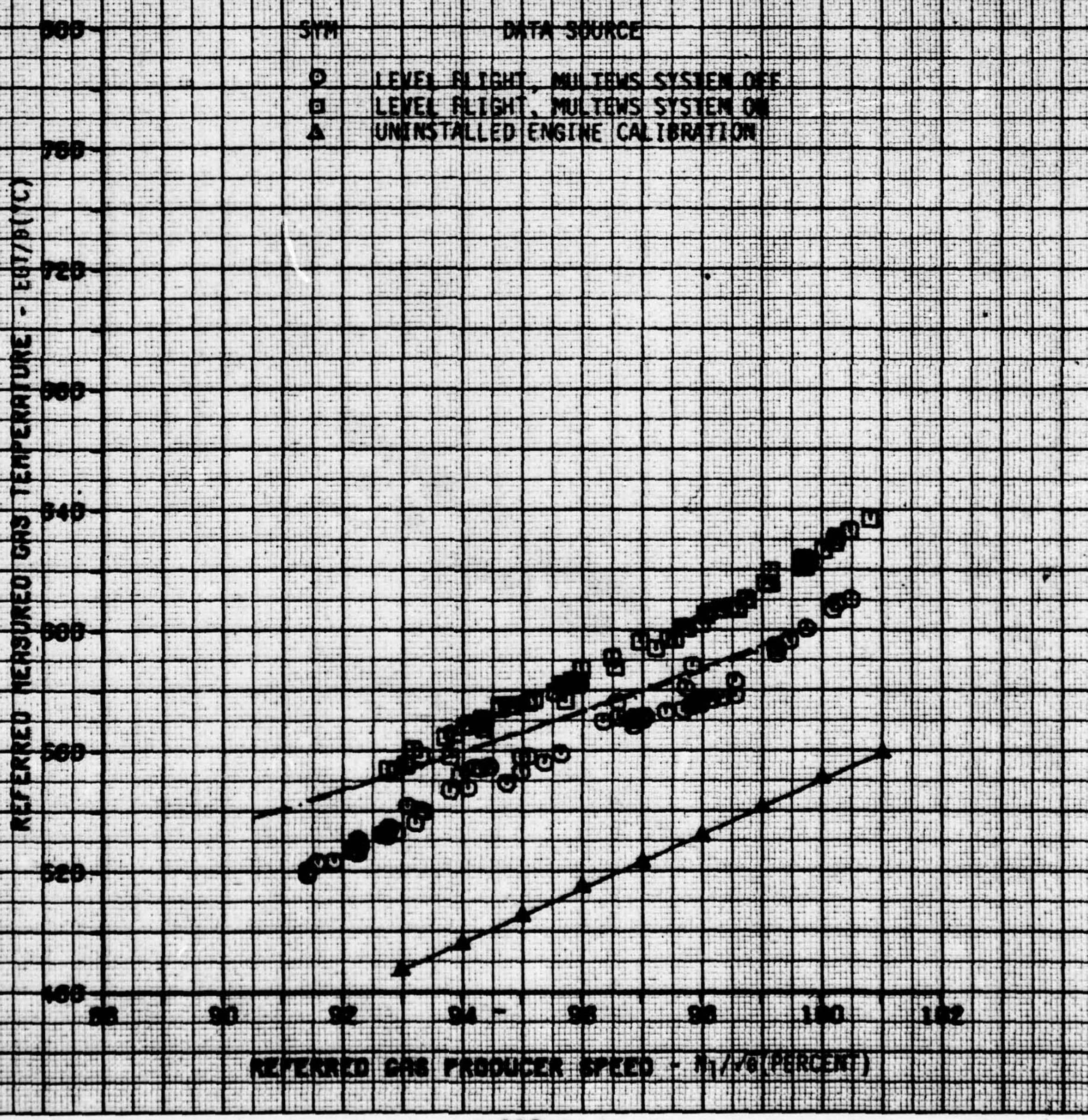


FIGURE 90

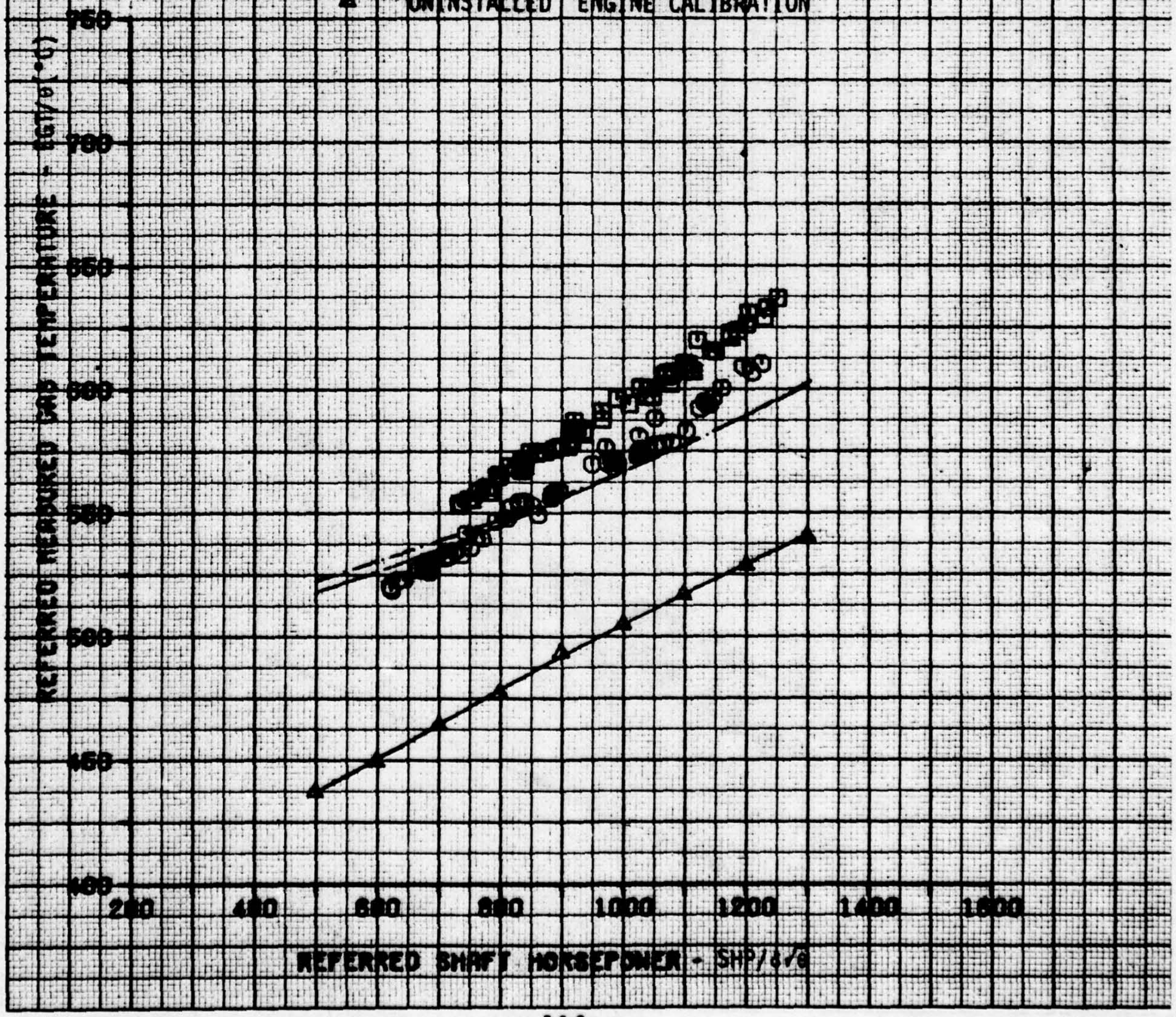
REFERRED ENGINE CHARACTERISTICS

JUH-1H USA S/N 74-22356

LYCOMING ENGINE T53-L-13B S/N LE12924X

NOTES:
1. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 7 , APP A).
2. DATA OBTAINED IN LEVEL FLIGHT.
3. LONG DASHED LINE - MULTEWS OFF - OBTAINED FROM ENGINE SPEC (REF 8 , APP A), 1.35% BLEED AIR LOSS 8.4SHP ACCESSORY LOSS.
4. DOT-DASHED LINE - MULTEWS ON - OBTAINED FROM ENGINE SPEC (REF 8 , APP A), 4% BLEED AIR LOSS 8.8SHP ACCESSORY LOSS.

SYM	DATA SOURCE
⊙	LEVEL FLIGHT, MULTEWS SYSTEM OFF
⊡	LEVEL FLIGHT, MULTEWS SYSTEM ON
▲	UNINSTALLED ENGINE CALIBRATION



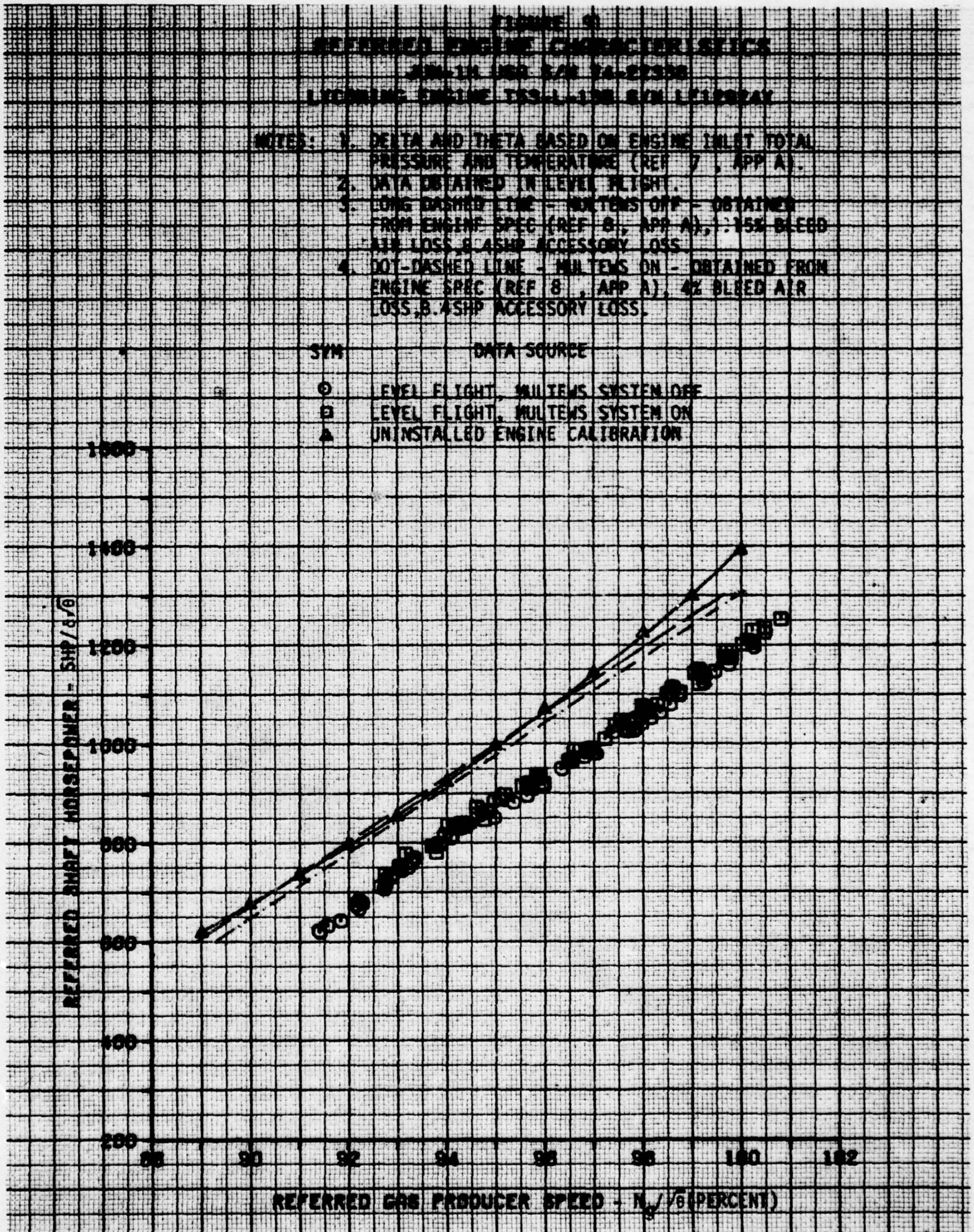


FIGURE 9
REFERRED ENGINE CHARACTERISTICS
NOTES: 1. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 7, APP A).
2. DATA OBTAINED IN LEVEL FLIGHT.
3. LONG DASHED LINE - MULTEWS OFF - OBTAINED FROM ENGINE SPEC (REF 8, APP A), 1.15% BLEED AIR LOSS,8.4SHP ACCESSORY LOSS.
4. DOT-DASHED LINE - MULTEWS ON - OBTAINED FROM ENGINE SPEC (REF 8, APP A), 4% BLEED AIR LOSS,8.4SHP ACCESSORY LOSS.
SYM
DATA SOURCE
LEVEL FLIGHT, MULTEWS SYSTEM OFF
LEVEL FLIGHT, MULTEWS SYSTEM ON
UNINSTALLED ENGINE CALIBRATION
REFERRED SHAFT HORSEPOWER - SHP/δ√θ
1600
1400
1200
1000
800
600
400
200
88
90
92
94
96
98
100
102
REFERRED GAS PRODUCER SPEED - N/√θ (PERCENT)

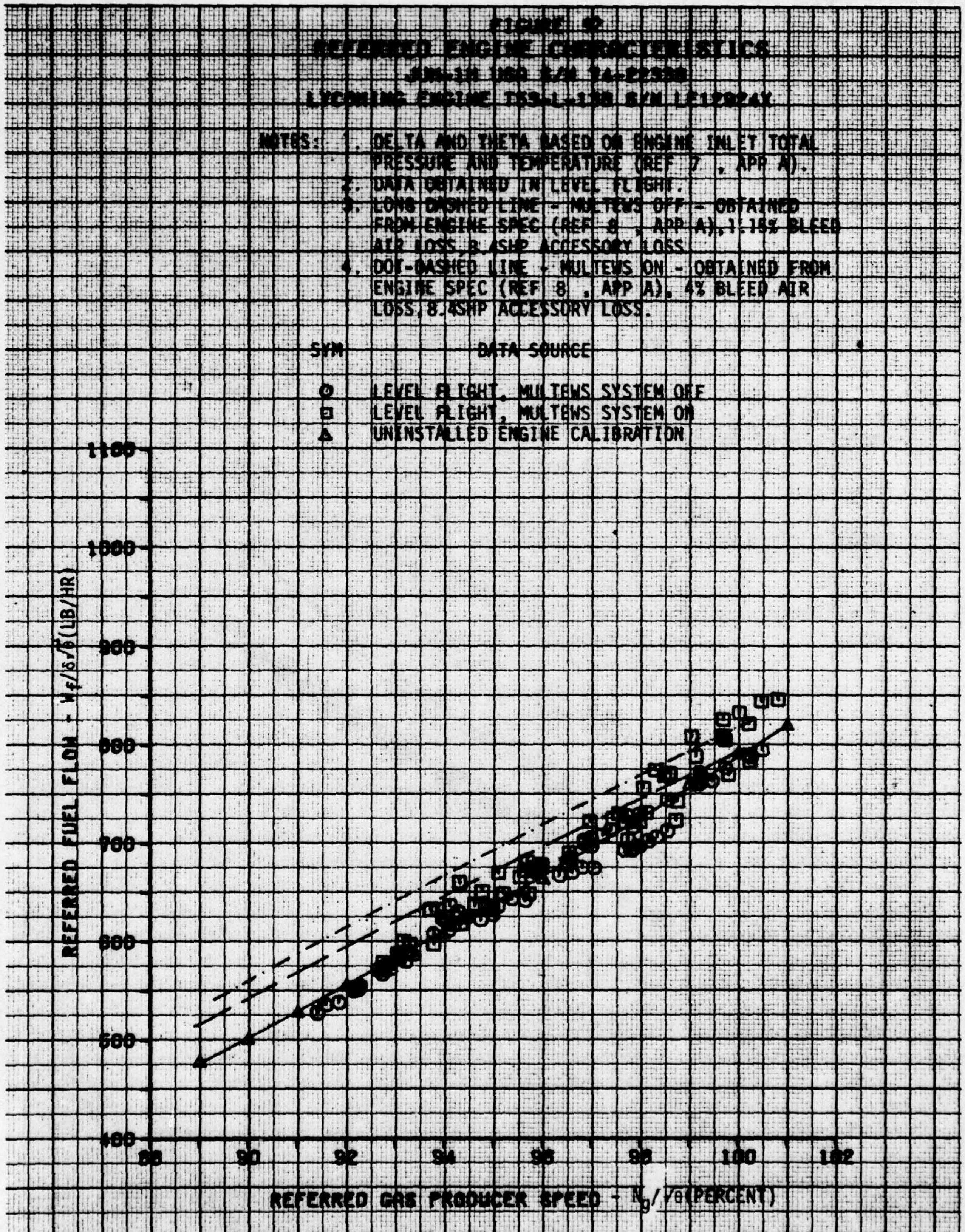

REFERRED ENGINE CHARACTERISTICS
LYCOMING ENGINE
NOTES: 1. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 7 , APP A).
2. DATA OBTAINED IN LEVEL FLIGHT.
3. LONG DASHED LINE - MULTEWS OFF - OBTAINED FROM ENGINE SPEC (REF 8 , APP A), 1.15% BLEED AIR LOSS, 8.4SHP ACCESSORY LOSS.
4. DOT-DASHED LINE - MULTEWS ON - OBTAINED FROM ENGINE SPEC (REF 8 , APP A), 4% BLEED AIR LOSS, 8.4SHP ACCESSORY LOSS.
SYM
DATA SOURCE
LEVEL FLIGHT, MULTEWS SYSTEM OFF
LEVEL FLIGHT, MULTEWS SYSTEM ON
UNINSTALLED ENGINE CALIBRATION
1100
1000
900
800
700
600
500
400
88
90
92
94
96
98
100
102
REFERRED FUEL FLOW - $W_f/\delta\sqrt{\theta}$ (LB/HR)
REFERRED GAS PRODUCER SPEED - $N_g/\sqrt{\theta}$ (PERCENT)

FIGURE 93
MAXIMUM CONTINUOUS SHAFT HORSEPOWER AVAILABLE
JUH-1H T53-L-13
6600 ENGINE OUTPUT SHAFT RPM
CLEAN CONFIGURATION

NOTES: Based on Model LTC1K-4 Specification Number 104.33 corrected for the following conditions:

1. Compressor inlet temperature rise = 1°C
2. Compressor inlet pressure ratio = .987
3. Air Bleed = 1.15 percent of total air flow
4. Horsepower extracted = 8.4 horsepower
5. Exhaust losses = zero
6. Zero airspeed

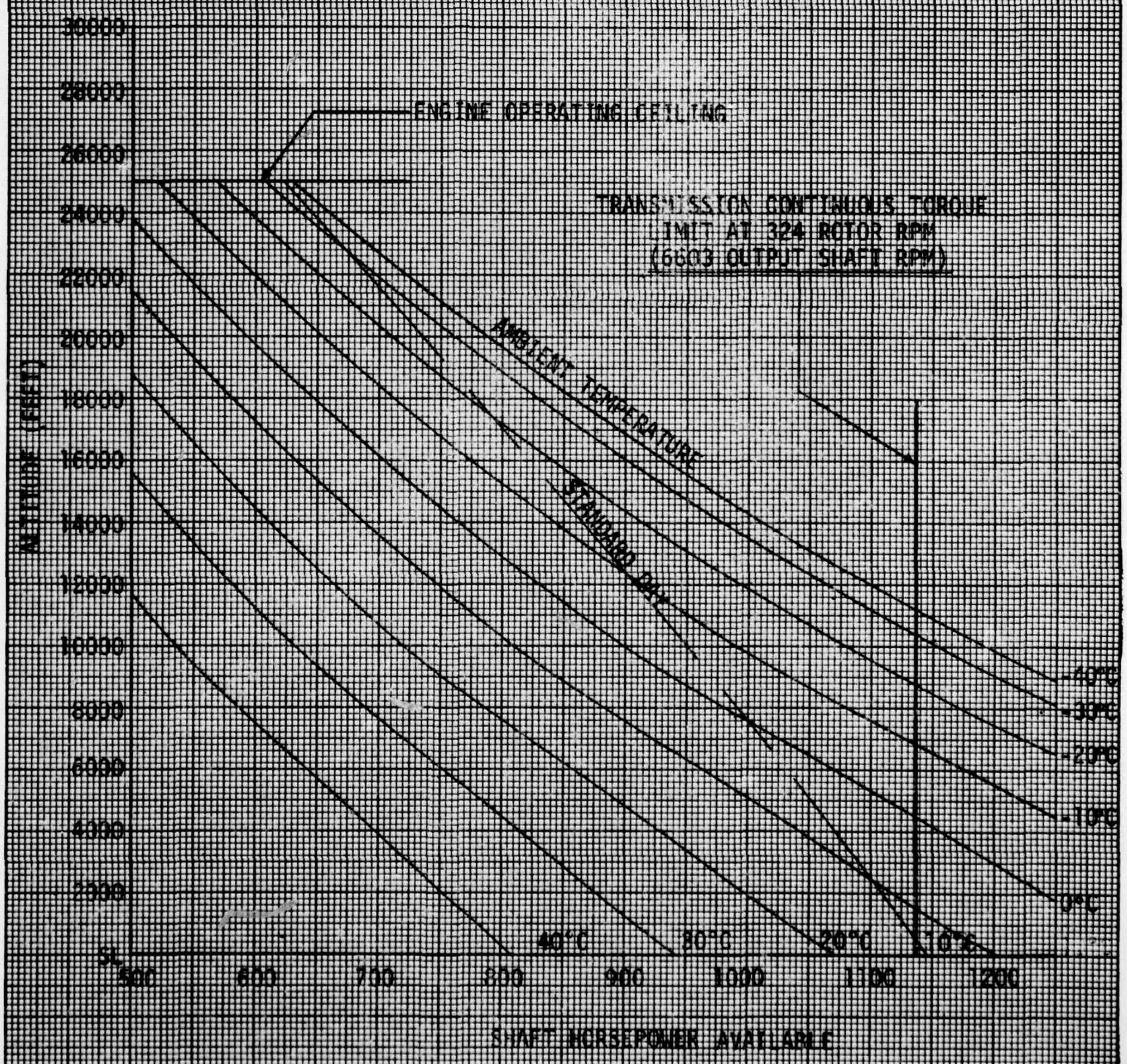


FIGURE 94
EFFECT OF AIRSPEED ON
MAXIMUM CONTINUOUS POWER AVAILABLE
JUH-1H T53-L-13
6600 ENGINE OUTPUT SHAFT RPM
STANDARD DAY
CLEAN CONFIGURATION

NOTES: Based on Model
corrected for the following installation conditions:

1. Compressor inlet temperature rise = 1°C
2. Air Bleed = 1.15 percent of total airflow
3. Horsepower extracted = 8.4 horsepower
4. Exhaust losses = zero
5. Bleed air heater = OFF
6. Anti-ice = OFF
7. Compressor inlet pressure ratios shown for particle separator - barrier filter [illegible] A

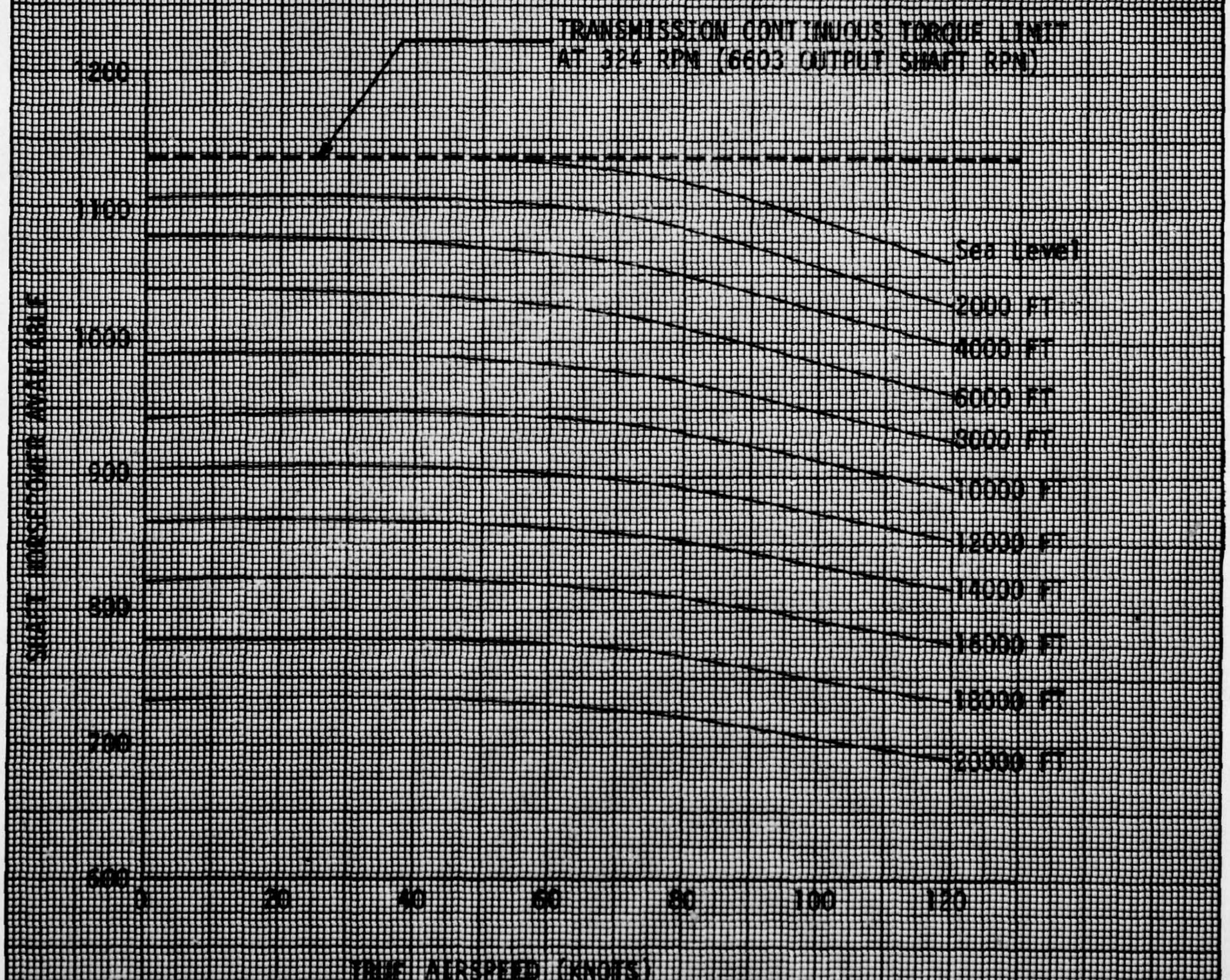


FIGURE 95
MAXIMUM CONTINUOUS SHAFT HORSEPOWER AVAILABLE
UH-1H T53-L-13
6600 ENGINE OUTPUT SHAFT RPM
[illegible] CONFIGURATION

NOTES: Based on Model LTC1K-4 Specification No. 104.33 corrected for the following installation conditions:
1. Compressor inlet temperature rise = 1°C
2. Compressor inlet pressure ratio = .987
3. Air bleed - [illegible] percent of total airflow
4. Horsepower extracted - 8.4 horsepower
5. Exhaust losses = zero
6. Zero airspeed

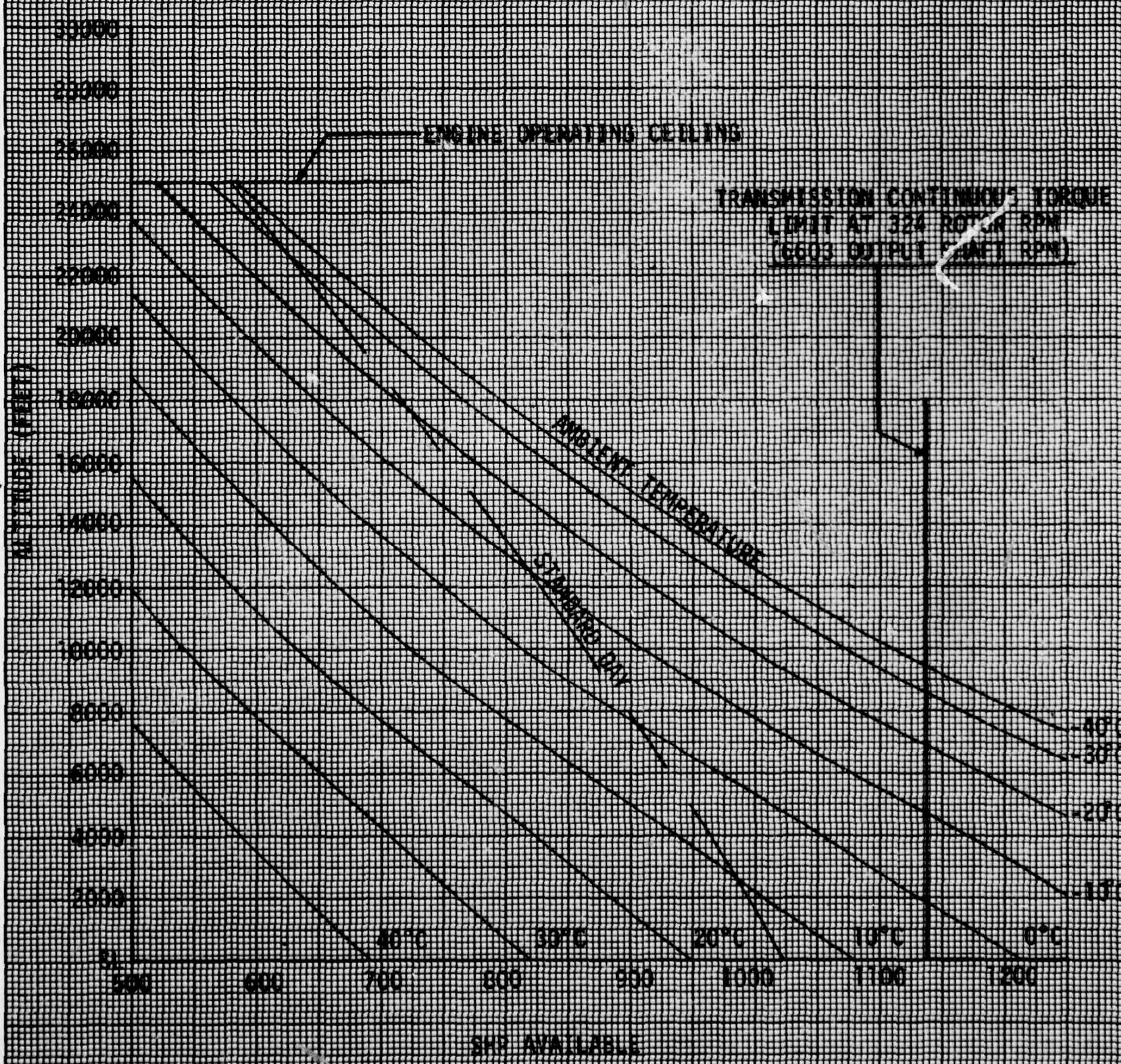


FIGURE 96
EFFECT OF AIRSPEED ON
MAXIMUM CONTINUOUS POWER AVAILABLE
JUH-1H T53-L-13
6600 ENGINE OUTPUT SHAFT RPM
STANDARD DAY
MULTEWS CONFIGURATION

NOTES: Based on Model
Corrected for the following installation conditions:
1. Compressor inlet temperature rise = 1°C
2. Air Bleed = 4.0 percent of total airflow
3. Horsepower extracted = 8.4 horsepower
4. Exhaust losses = zero
5. Bleed air heater = OFF
6. Anti-ice = OFF
7. Compressor inlet pressure ratios shown for particle separator - barrier filter deflector A

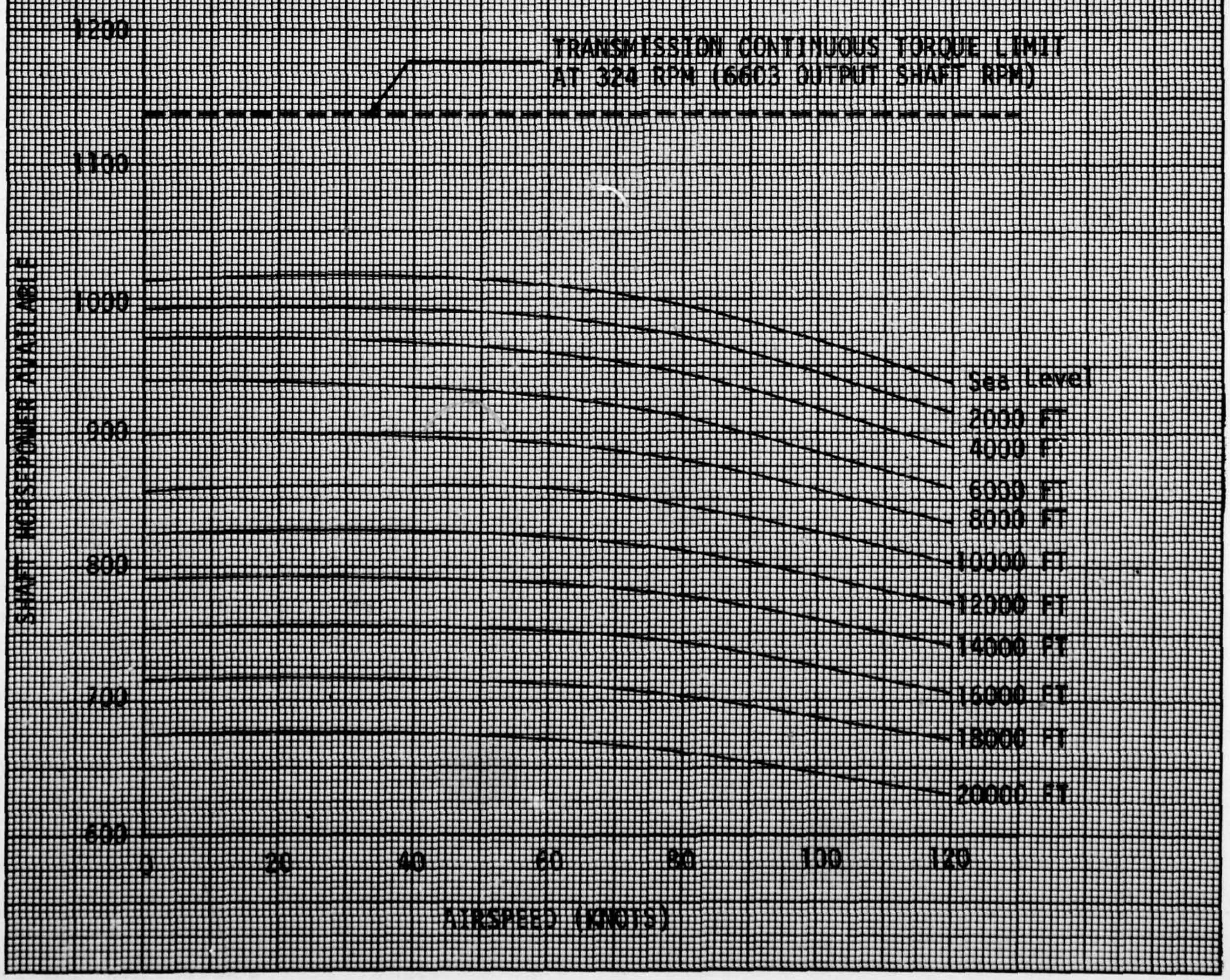


FIGURE 97
ENGINE OSCILLATIONS
JUH-1H USA S/N 74-22338

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8940	135.8 (MID)	0.7 (RT)	5240	25.0	324	76

NOTES: 1. MULTEMS CONFIGURATION
2. CLIMBING FLIGHT
3. STANDARD UH-1H FUEL CONTROL

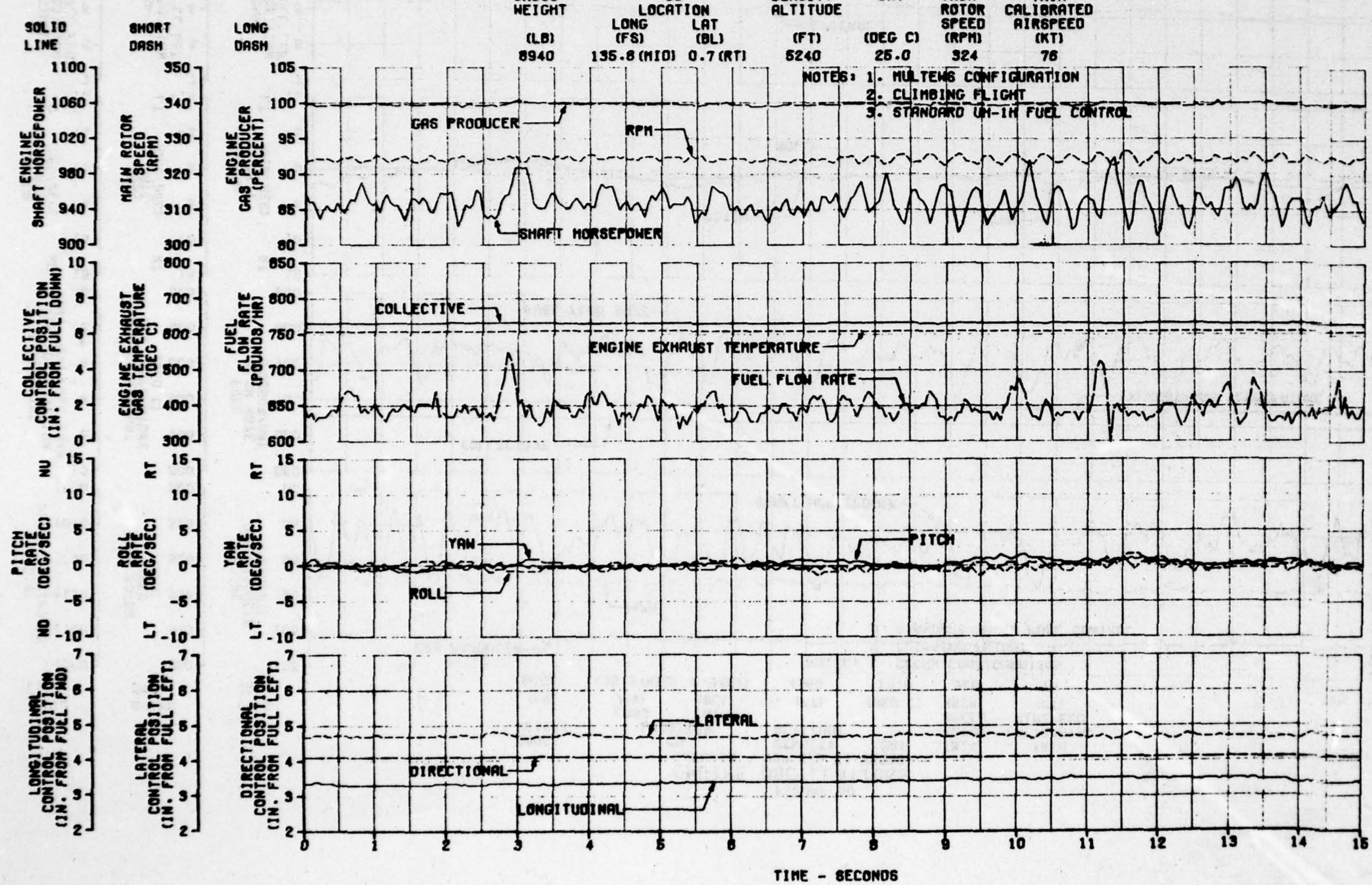


FIGURE 98
ENGINE OSCILLATIONS

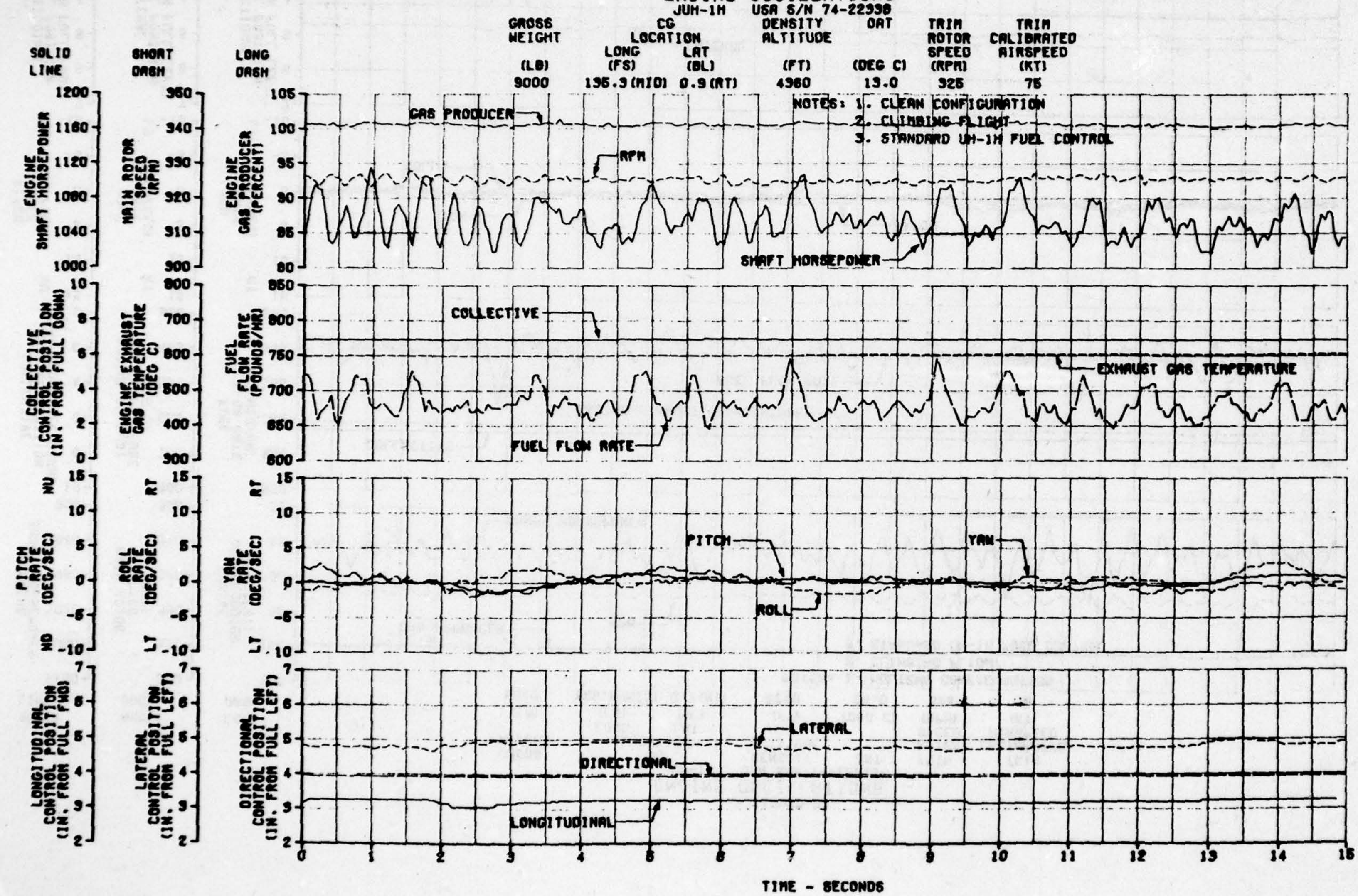


FIGURE 99

ENGINE OSCILLATIONS

JUH-1H USA S/N 74-22338

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
9420	140.4 (AFT)	0.4 (RT)	4400	16.0	323	57

NOTES: 1. MULTEMS CONFIGURATION
2. CLIMBING FLIGHT
3. TEST FUEL CONTROL (L-709)

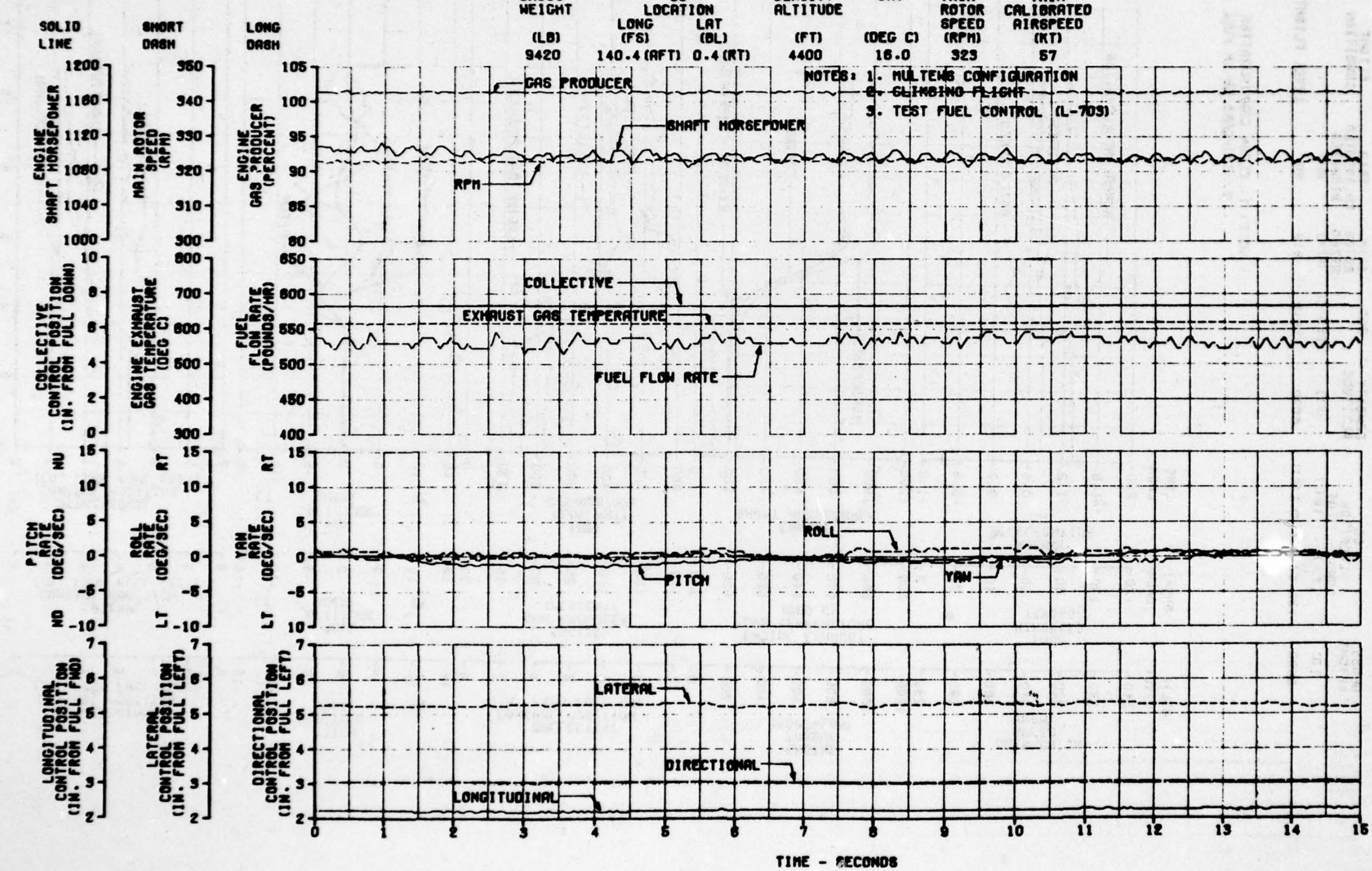


FIGURE 100
COLLECTIVE PULL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION
8960	136.5 (MID)	0.4 (RT)	6020	16.0	314	60	LEVEL FLIGHT

NOTE: 1. CLEAN CONFIGURATION
2. STANDARD UH-1M FUEL CONTROL

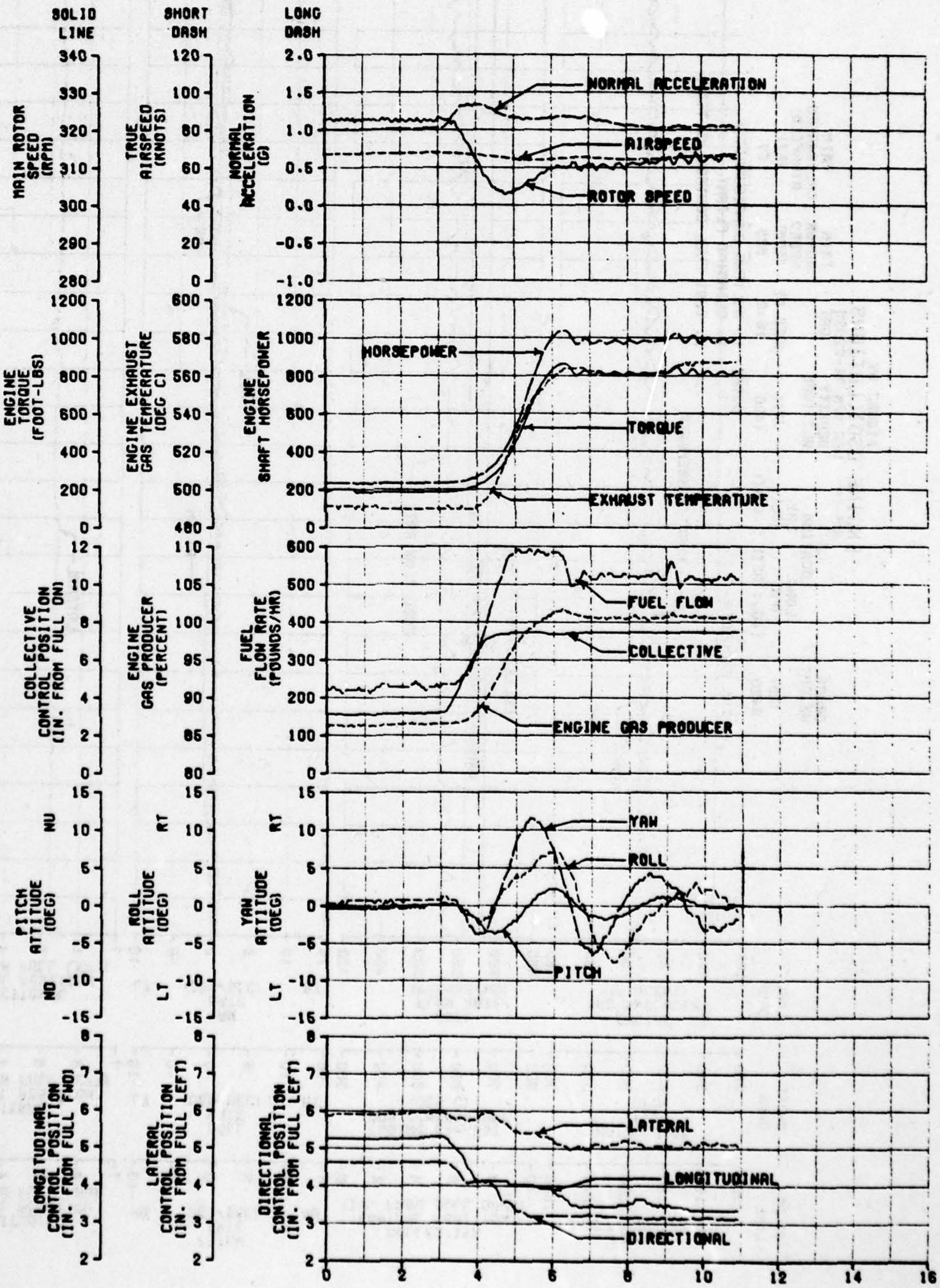
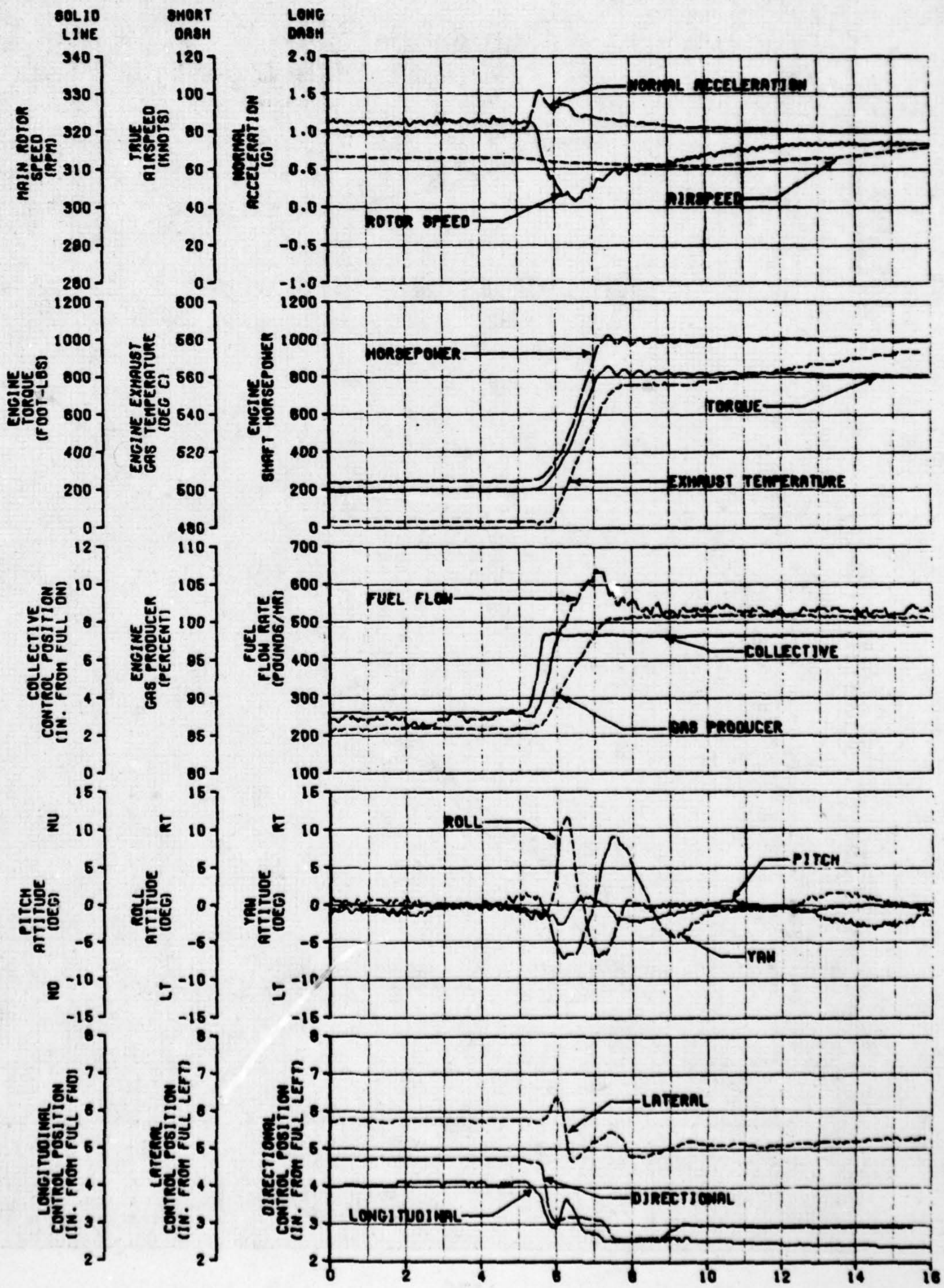
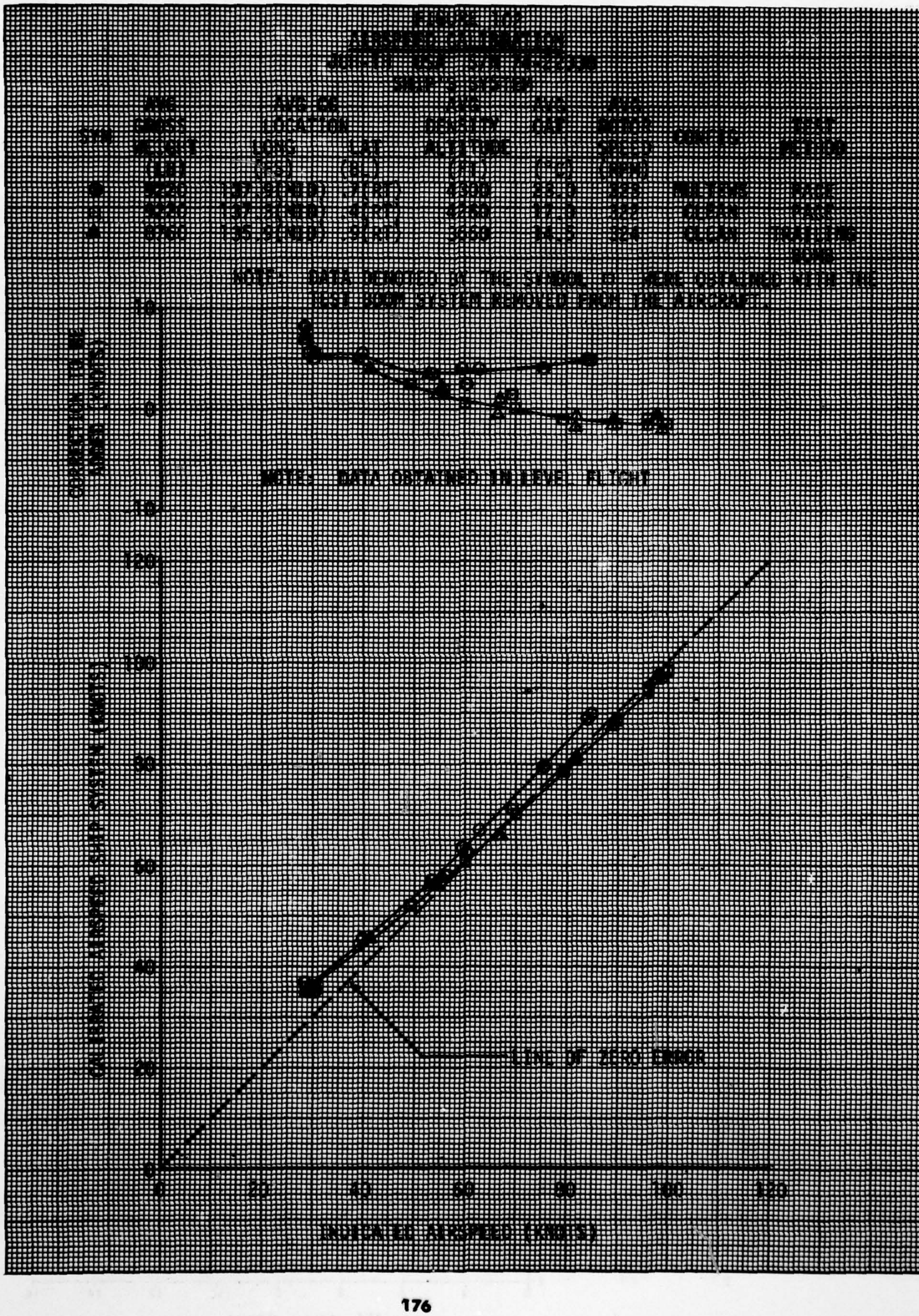


FIGURE 101
COLLECTIVE PULL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION
8080	138.3 (AFT)	0.4 (RT)	6300	16.0	319	60	LEVEL FLIGHT

NOTE: 1. MULTENS CONFIGURATION
2. TEST FUEL CONTROL (L-788)




AIRSPEED CALIBRATION
SHIP'S SYSTEM
NOTE: DATA DENOTED BY THE SYMBOL WERE OBTAINED WITH THE TEST BOOM SYSTEM REMOVED FROM THE AIRCRAFT.
CORRECTION TO BE ADDED (KNOTS)
NOTE: DATA OBTAINED IN LEVEL FLIGHT
CALIBRATED AIRSPEED SHIP SYSTEM (KNOTS)
LINE OF ZERO ERROR
0
20
40
60
80
100
120
INDICATED AIRSPEED (KNOTS)

APPENDIX F. EQUIPMENT PERFORMANCE REPORT

EQUIPMENT PERFORMANCE REPORT
(AVSCOM Reg 70-13)

DATE: 22 August 1977
OFFICE SYMBOL: DAVTE-TA

TO:	FROM:
COMMANDER US ARMY AVIATION SYSTEMS COMMAND ATTN: DRSAV-EQ PO BOX 209 ST. LOUIS, MISSOURI 63166	Commander US Army Aviation Engineering Flight Acty ATTN: DAVTE-TA Edwards AFB, CA 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
77-09-01	77-09	MULTEWS

SECTION A - MAJOR ITEM DATA

4. MODEL JUH-1H	5. SERIAL NO 74-22338
6. QUANTITY 1 ea.	7. MANUFACTURER Bell Helicopter Textron

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION Ground Handling Wheel Assembly (212)	9. NSN
10. MFR PART NO	11. MANUFACTURER Bell Helicopter Textron
12. QUANTITY 1 ea.	13. NEXT ASSEMBLY

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
X a. OPERATION	Dry, level, hangar	X a. DEFICIENCY	X REPLACED
b. MAINTENANCE	floor (concrete)	b. SHORTCOMING	REPAIRED
c.	UH-1 8750 lbs.	c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

18. DATE AND HOUR OF INCIDENT 19 AUG 77 0545 hrs.

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY *(Deficiencies and Shortcomings are subject to reclassification)*

In preparation for flight, ground handling wheels were being pumped up to move aircraft outside of hangar. The UH-1H being moved was configured for MULTEWS and was at a gross weight of 8750 lbs. After raising the right aircraft skid approximately one inch, the unit failed in two places dropping the aircraft back to the ground. The 212 handling wheels are raised by hydraulic pressure on two separate rams that in turn move the main load bearing member down. The inboard ram failed at the point where it leaves the hydraulic pump - a threaded collar also failed at this point. The second fail point was where the ram attaches to the main load bearing member. The ram is attached by a hollow bolt with integral grease nipple. The bolt was sheared in two places leaving a plug of bolt material in the main load bearing member attach point. The 212 handling wheels were being used due to restricted antenna clearance on the MULTEWS configuration and due to the high gross weights.

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
SHERWOOD C. SPRING, CPT, SC Project Pilot 76336	Sherwood C Spring

AV Form 1002, 1 May 76 — Edition of 1 Aug 74, may be used.

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